3.5 HYDROLOGY

3.5.1 INTRODUCTION

During the summer of 2003, the Robert and Wedge Canyon Fires burned approximately 110,885 acres of Flathead National Forest (FNF), Glacier National Park (GNP), State of Montana, and private lands primarily within the North Fork of the Flathead River drainage. The Robert Fire was human caused and was spotted on July 23, 2003. The Wedge Canyon Fire was initiated by a lightning strike and spotted in the early afternoon of July 18, 2003.

Of the 57,570 acres of land that burned in the Robert Fire, approximately 12,852 acres (22%) occurred within the FNF. Of the 53,315 acres that burned within the Wedge Canyon Fire, approximately 20,628 acres (39%) occurred within the Forest boundary.

The FNF is proposing to salvage log dead trees and trees damaged by the fire in up to 5,822 acres within the 2 fire areas. This includes approximately 3,090 acres within the Robert Fire and roughly 2,732 acres within the Wedge Canyon Fire. These acres represent the upper limit of salvage that could occur within the fire boundary areas. Other concerns, like site specific salvage prescriptions, logging system changes, natural resource limitations and economic viability, may be uncovered in the future and would reduce acres of salvage to below 5,822 acres.

Of the 5,822 acres proposed for salvage, approximately 2,685 acres (46%) will be helicopter logged, 963 acres (17%) cable logged, and 2,174 acres (37%) tractor logged. Approximately 2.3 miles of new temporary road will be constructed as well as the opening of approximately 2.5 miles of historic road templates to access certain units. No new permanent roads will be constructed for the project. All temporary roads constructed or opened for the project would be closed and rehabilitated after salvage activities.

Approximately 47 acres of Riparian Conservation Habitat Areas (RHCAs), as defined by the Inland Native Fish Strategy, are proposed for salvage logging activity. These acres are adjacent to the Teepee Creek Road in the Wedge Canyon Fire area and the McGinnis Creek Road in the Robert Fire Area.

In addition to salvage logging activity, some salvage units will be planted with native tree seedlings. Some non-salvage areas will be planted with native trees and shrubs to promote regeneration and species diversity as well. Approximately 2,840 acres within and outside of salvage units will be planted. Approximately 2,200 acres in the Wedge Canyon Fire area and 640 acres in the Robert Fire area will be planted with these trees and shrubs. Plantings will focus mainly on riparian areas that experienced a high severity burn.

Following salvage harvest, fuel reduction and site preparation activities may occur within some units depending on soil resource concerns. In addition, light soil scarification or slashing of unmerchantable material may occur within certain units to test the effects on vegetation recovery and huckleberry production.

The proposed action would also include activities to change access management within the Lower Whale and Canyon McGinnis grizzly bear subunits to reduce current open motorized access density and total motorized access density, and improve security core for grizzly bears.

Approximately five miles of open yearlong/seasonally open road would be closed yearlong to wheeled motorized vehicles within these two grizzly bear subunits. In addition to changes to open roads, approximately 16 miles of road would be decommissioned in both grizzly bear subunits. Road decommissioning would include actions to minimize the potential for future sedimentation of streams or noxious weed development. These actions would include placement of numerous waterbars, culvert removals, grass seeding, slash or debris placement on roads, planting shrubs, or spraying herbicides on existing noxious weed infestations.

Culvert removal and stream restoration would occur where roads to be decommissioned intersect streams. To reduce the amount of ground disturbance, cross drain culverts would typically not be removed but waterbars would be placed nearby. The amount of physical altering of the road template from culvert removal or water bar creation would vary according to the sites involved. For a detailed map of the project proposal, please see project file.

Project Area

Direct and Indirect Effects for the Robert Fire will be analyzed within the 12,852 acres that burned on Flathead National Forest land. Direct and Indirect Effects for the Wedge Canyon Fire will be analyzed within the 20,628 acres that burned within the forest boundary as well. The Robert-Wedge Post-Fire Project cumulative effects area will include all 6th Order HUCS affected by the fires. Sixth Order HUCS were used for the cumulative effects area because the majority of the land is owned by the Flathead National Forest (fewer land owners make it easier to know past, present, and future land management activity) and the watershed sizes are manageable in terms of assessing impacts from land management activity. The next step would have been to assess the North Fork of the Flathead River. The North Fork of the Flathead River is located in 2 countries, Forest Service, Park Service, State of Montana, and private lands to name a few. The watershed is too large and complex to realistically assess the impacts of past, present, and future land use activities. The 6th Order cumulative effects watersheds are diluted by the North Fork of the Flathead River when they join together, theoretically making effects from the Robert and Wedge Canyon Project Areas undetectable. Effects are more easily detected in the smaller cumulative effects watersheds. Cumulative effects watersheds will be described in detail in the affected environment section below. Cumulative effects watersheds for the Robert Fire include: Canyon Creek and all tributaries, Deep Creek and all tributaries, Hell Roaring Creek and all tributaries, and all unnamed drainages that flow directly to the North Fork of the Flathead River (called face drainages). Cumulative effects watersheds for the Wedge Canyon Fire include: Whale Creek and all tributaries, Tepee Creek and all tributaries, Trail Creek and all tributaries (including Yakinikak, and all unnamed drainages that flow directly to the North Fork of the Flathead River (called face drainages).

3.5.2 AFFECTED ENVIRONMENT

All streams affected by the Robert and Wedge Canyon Fires on FNF lands are within the North Fork of the Flathead River watershed, which occupies portions of northwest Montana and southeast British Columbia, Canada. Major tributaries that burned within the Robert Fire on FNF lands include: unnamed north/northeast facing drainages that flow directly to the North Fork of the Flathead River, Hell Roaring Creek, Deep Creek, McGinnis Creek, Depuy Creek, and lower portions of Kimmerly and Canyon Creeks. Major tributaries that burned within the Wedge Canyon Fire on FNF lands include: unnamed east facing drainages that drain directly to the North Fork Flathead River, Tepee Creek, Hornet Creek, Cleft Creek, and lower portions of Whale and Trail Creeks. Table 98 and Table 99 list these watersheds, where the stream flows to, watershed size and the percent of the watershed burned during the Robert and Wedge Canyon Fires.

Table 98. Watersheds affected by the Robert Fire with drainage size and percentage of basin burned in the fire.

Watershed Name	Tributary to	Basin Size – Acres (sq. miles)	Acres and Percentage of basin burned in Fires
Hell Roaring, Dry, and Deep Creeks and First Order unnamed tributaries to the NF Flathead River	North Fork of the Flathead	5,857 acres (9.1 sq. miles)	5,679 acres (97%)
Deep Creek	North Fork of the Flathead	1,862 acres (2.9 sq. miles)	1,505 acres (80.8%)
McGinnis Creek	Canyon Creek	4,193 acres (6.6 sq. miles)	4,193 acres (100%)
Kimmerly Creek	Canyon Creek	4,287 acres (6.7 sq. miles)	348 acres (8.1%)
Depuy Creek	Canyon Creek	1,444 acres (2.3 sq. miles)	1,439 acres (99.7%)
Canyon Creek	North Fork of the Flathead	19,041 acres (29.8 sq. miles)	6,841 acres (36%)

Table 99. Watersheds affected by the Wedge Canyon Fire with drainage size and percentage of basin burned in the fire.

Watershed Name	Tributary to	Basin Size – Acres (sq. miles)	Acres and Percentage of basin burned in Fires
Unnamed tribs. draining to the NF Flathead River within the WC Fire	North Fork of the Flathead	3,889 acres (6.1 sq. miles)	2,030 acres (52%)
Tepee Creek	North Fork of the Flathead	9,512 acres (14.9 sq. miles)	7,663 acres (81%)
Hornet Creek	Whale Creek	1,827 acres (2.9 sq. miles)	1,827 acres (100%)
Whale Creek	North Fork of the Flathead	40,959 acres (64 sq. miles)	4,806 acres (11.7%)
Cleft Creek	Trail Creek	1,723 acres (2.7 sq. miles)	1,050 acres (60.9%)
Trail Ck./ Yakinikak Ck.	North Fork of the Flathead	45,233 acres (70.7 sq. miles)	7,452 acres (16%)

Robert Fire

Elevations within the Robert Fire burn area range from 3,160 feet where the North Fork of the Flathead River leaves the Robert fire boundary to 6,331 feet at the head of the Deep Creek drainage. Depuy Creek is a first order drainage. Hell Roaring and Deep Creeks are second order drainages. Kimmerly and McGinnis Creeks are third order drainages while Canyon Creek is a fourth order stream. The length of the main stems and slope ranges of the six major named streams within the Robert Fire Project Area are shown in Table 100.

Table 100. Stream Lengths of the main stems of the major drainages found within the Robert Fire Burn Area.

Stream Name	Length of Main Stem (miles)
Hell Roaring Creek	1.9
Deep Creek	2.6
McGinnis Creek	4.9
Kimmerly Creek	3.7
Depuy Creek	2.8
Canyon Creek	10.9

The average annual precipitation in the Robert Fire Project Area ranges from approximately 20 inches in the North Fork of the Flathead River Valley to 59 in the headwaters of Deep Creek. Approximately 60% of the precipitation falls as snow from November through late March/early April. Stream flow begins to increase in April as the snow pack melts with warming spring temperatures. Stream flows typically peak in late May or June as the snow pack melts. Not all snowmelt or rainfall of the study area becomes surface runoff, at least not immediately. Some may infiltrate into the ground to become groundwater that percolates downward in the soil and bedrock and resurfaces in wet areas, small ponds, and perennial streams at various elevations below the point of infiltration. Slow release of groundwater provides stream base flow starting in mid July to mid September.

Streams within the Robert Fire area are not considered critical habitat for the threatened bull trout. Canyon, McGinnis and Deep Creeks provide quality habitat for west slope cutthroat trout, a sensitive fish species on the Flathead National Forest.

Wedge Canyon Fire

Elevations within the Wedge Canyon Fire burn area range from 3,700 feet where the North Fork of the Flathead River leaves the Wedge Canyon fire boundary to about 7,300 feet on Cleft Rock Mountain. Hornet and Cleft Creeks are second order streams. Tepee Creek is a third order stream while Whale and Trail Creeks are fourth order basins. The length of the main stems and slope ranges of the six major streams within the Wedge Canyon Fire Project Area are shown in Table 101.

Table 101. Stream Lengths of the main stems of the major drainages found within the Wedge Canyon Fire Burn Area.

Stream Name	Length of Main Stem (miles)
Tepee Creek	11.6
Hornet Creek	3.0
Whale Creek	19.4
Cleft Creek	3.5
Trail Creek	21.6
Yakinikak Creek	11.1

The average annual precipitation in the Wedge Canyon Project Area ranges from approximately 20 inches in the North Fork of the Flathead River Valley to 79 in the headwaters of Teepee and Antley Creeks. Like the Robert project area, approximately 60% of the precipitation falls as snow from November through late March/early April. Peak flows, base flows, and general hydrologic regime for streams within the Wedge Canyon Project Area are similar those within the Robert Fire Project Area.

Whale and Trail Creeks are considered critical habitat for the threatened bull trout. Tepee Creek is an important stream for the Westside Cutthroat Trout. Whale, Trail, and Tepee Creeks all contain Bull and Westside Cutthroat Trout as well as mountain whitefish and various sculpin species.

Stream Flow within the Robert and Wedge Canyon Project Areas

As previously described, peak streamflow usually occurs in late May or early June from spring snowmelt within both the Robert and Wedge Canyon Fire Project Areas. Flood flows rarely overtop the channel banks and erode adjacent land areas. High flows that erode the upper banks of the channel occur every three to five years. The last high flow was in the spring of 1997 from the snowmelt of an unusually deep snow pack. Figure 30 shows a comparison of the water flow in cubic feet/second for the 1992 water-year at the water-quality monitoring site in lower Big Creek and on the main stem of the North Fork of the Flathead River, at Glacier Rim. No hydrograph data is available for the streams that drain the Robert Fire Project Area. Hydrograph data is available for Whale Creek (Figure 31), which drains the Wedge Canyon Fire Project Area, at the bridge on Forest Road 486. This sight will be used as the representative hydrograph for the Wedge Canyon Project Area. Big Creek is a major tributary to the North Fork Flathead River and was affected by the Moose Fire in the summer of 2001. Big Creek is located adjacent to the Robert Fire Project Area to the north. Drainages within the Robert Fire Project Area respond in a similar hydrologic fashion as Big Creek. Therefore, the Big Creek hydrograph will be used to show a typical hydrograph for streams draining the Robert Fire Project Area.

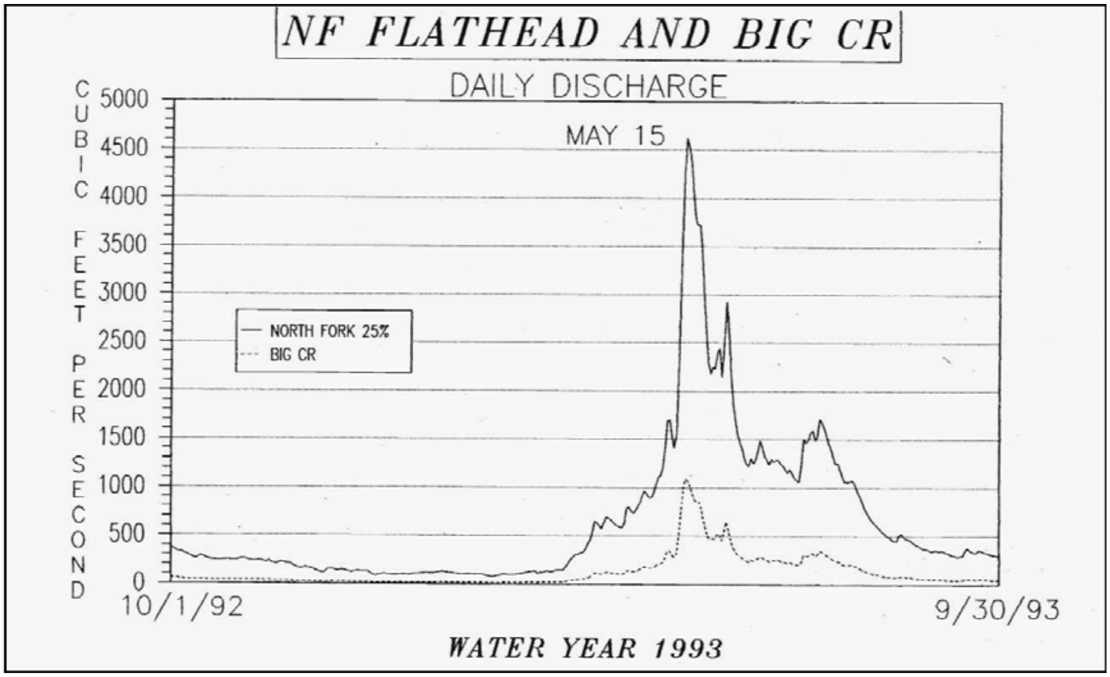

Figure 30. Comparison of the water flow at Glacier Rim for the North Fork of the Flathead River in comparison to Big Creek at Lookout Bridge for the 1993 water year. Big Creek has similar hydrological attributes as streams that drain the Robert Fire Project Area.

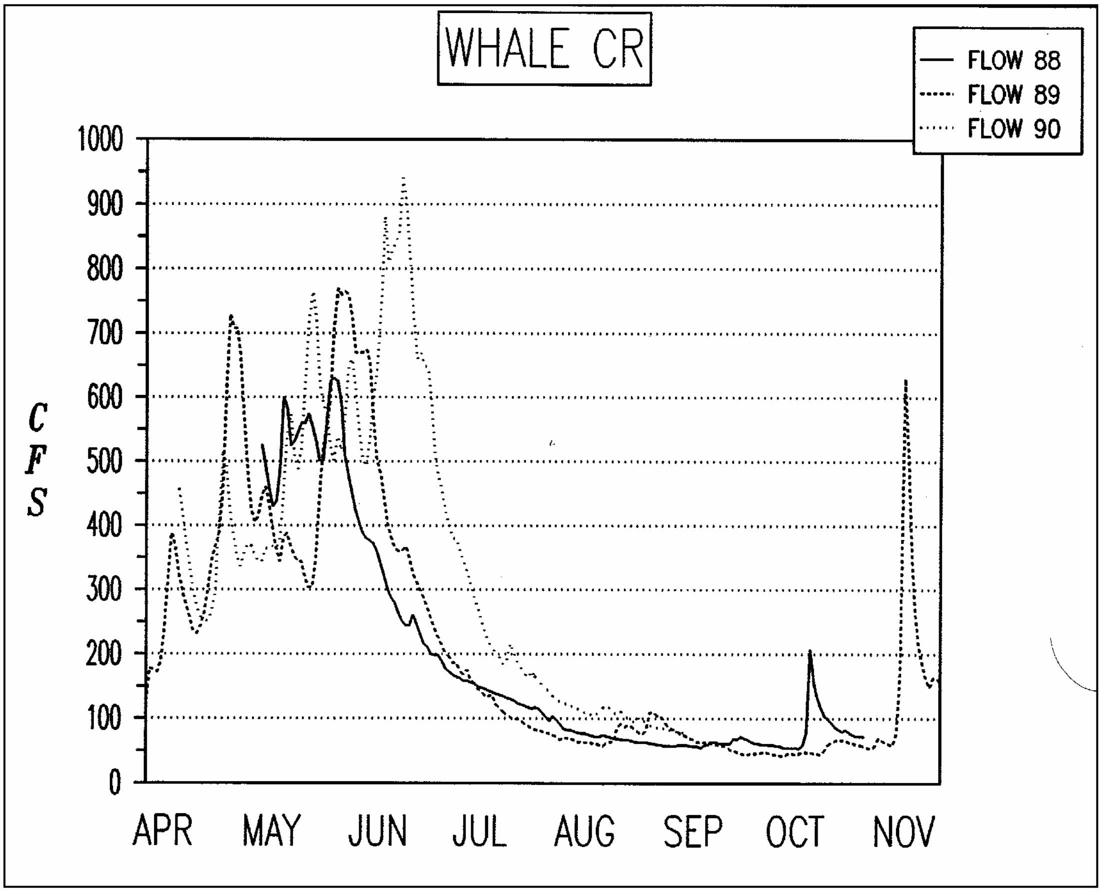

Figure 31. Comparison of water flow for 1988, 1989, and 1990 at the Forest Road 486 Bridge for Whale Creek. Typical peaks occur in late May to early June with base flows occurring from late July to early November. Whale Creek has similar hydrological attributes as streams that drain the Robert Fire Project Area.

Water Quality

The only historical water quality monitoring site located within close proximity to either the Robert or Wedge Canyon Fire Project Areas is FL7012. This site was located at the Lookout Bridge, about two miles upstream from the mouth of Big Creek. Starting in 1986, Big Creek was one of the watersheds where suspended sediments bedload sediments were measured to validate sediment yield assumptions made in the Forest Plan and the WATSED model. Table 102 displays the results of that monitoring data for seven years (1986-1992).

Table 102. Annual Sediment Yield for Big Creek at Lookout Bridge.

Monitoring Year	1986	1987	1988	1989	1990	1991	1992
Annual Sediment Yield (Tons/Mile Square/Year)	199.8	134.4	8.4	23.7	41.3	81.3	81.5

At this monitoring site the annual sediment yield is variable, as the streamflow increases the suspended and bedload sediment load increases. Sediment pulses occasionally move downstream after a mass failure or other major sediment producing action occurs upstream (i.e. fire). However, it is during the annual snowmelt peak discharge that sediment transport rates are predictably high and the duration of high sediment transport rates seems to be a function of the duration of bank full and higher streamflow. A graph illustrating the relationship of total suspended sediment and bedload to stream discharge for FL7012 are displayed in Figure 32.

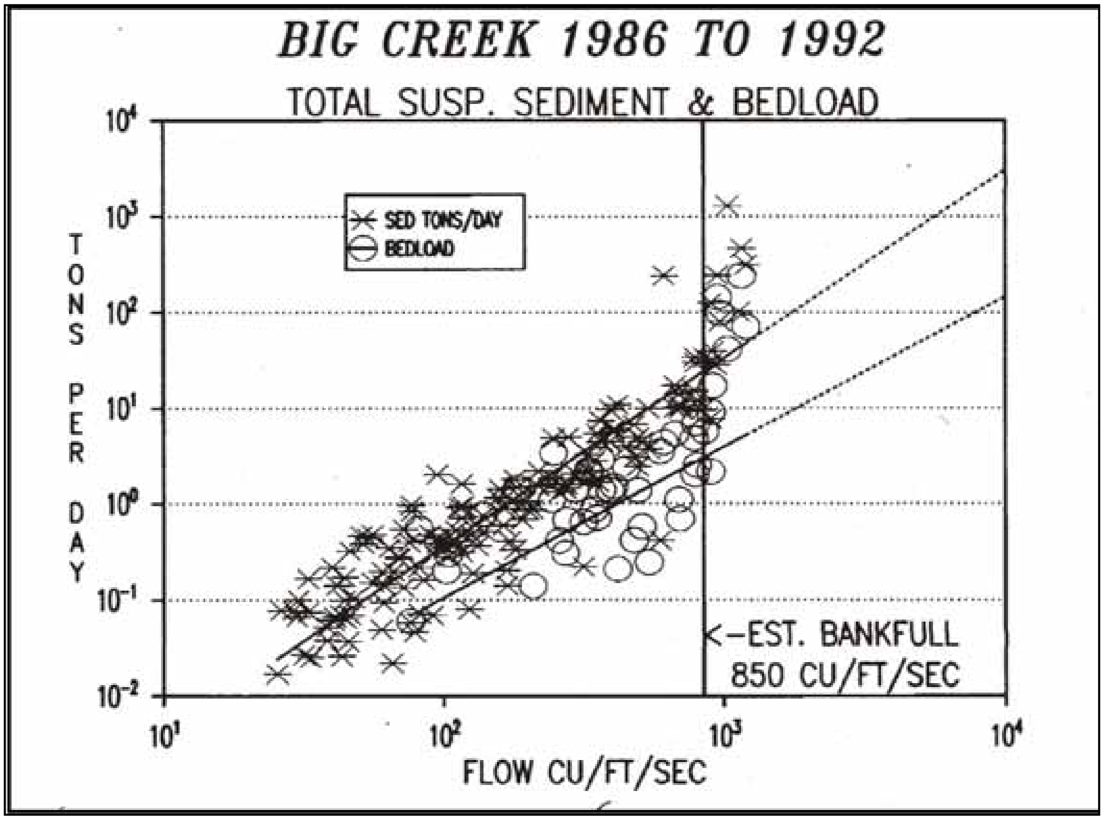

Figure 32. The total suspended sediment and bedload versus stream discharge in Big Creek for the years 1986 to 1992. Big Creek was used to illustrate typical suspended and bedload dynamics within the Robert and Wedge Canyon Project Area watersheds.

Suspended sediment/discharge samples were also collected at monitoring site (FL7007) located in the upper reaches of Big Creek, about one-half mile above Nicola Creek. Between 1979 and 1981, a total of 10 samples were gathered. Suspended sediment concentration was not significantly correlated with discharge from these data (Anderson 1988). It is assumed that bedload and suspended sediment dynamics for Big Creek will be similar to those watersheds within both the Robert and Wedge Canyon Fire Project Areas due to its close proximity, similar geology, soils, and land management. These examples are used here for that reason.

Water Quality Standards and Concerns

The State of Montana has classified the waters within the Robert and Wedge Canyon Fire Areas as B-1. Waters classified as B-1 are suitable for drinking, culinary, and food processing purposes after conventional treatment. Water quality must also be suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

Additional criteria specific to sediment are found within Section 17.30.623(2)(f) of Montana Water Quality Standards where it is stated that: "no increases are allowed above naturally occurring concentrations of sediment, settle-able solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife." Naturally occurring is as defined by MCA 17.30.602 (17), includes conditions or materials present during runoff from developed land where all reasonable land, soil, and water conservation practices (BMPs) have been applied. Reasonable practices include methods, measures or practices that protect present and reasonably anticipated beneficial uses.

All water bodies within the Robert and Wedge Canyon Cumulative Effects Project Areas are meeting beneficial uses for water quality except Whale Creek from it's headwaters to the confluence with the North Fork of the Flathead River. Whale Creek was initially listed on the State of Montana 303 (d) List in 1996 for sediment. The stream is regarded as a core/priority watershed for bull trout by the Montana Department of Fish, Wildlife, and Parks. Low fish population numbers and high fine stream sediments in bull trout spawning gravels found in McNeil core samples taken in the early 1990's prompted listing the stream. Reasons for listing Whale Creek include silvicultural practices and roads (including road crossings). The stream has been listed on subsequent 303(d) Lists in 2000 and 2004. An assessment to determine if Whale Creek needs a TMDL was initiated by the Flathead National Forest in July 2002. Work has been turned over to the EPA and the Montana Department of Environmental Quality, who are currently working to finish the assessment and make a final determination on the listing of Whale Creek.

Soil/Geology/Landform/Stream Type Characterization

The dominant soils in both the Robert and Wedge Canyon Project Areas are derived from Precambrian meta-sedimentary residual parent materials, predominantly argillite, siltite, quartzite, or limestone. Also, in the western portion of the project area boundaries there are Permian limestone and Tertiary siltstone deposits. The parent materials in valley bottoms of some portions of the fire include glacial till, glacial outwash, and glacial lacustrine deposits. The soils are typically moderately deep to shallow on the mountain side-slopes or ridges, and deep on toe-slopes and valley bottoms. Most soils usually have a volcanic ash influence surface layer with a silt loam texture, with coarse fragments ranging from 5 to 15 percent pebbles or gravels. The subsoils are typically silt loams or sandy loams, having 20 to 60 percent coarse fragments. The glacial outwash deposits have soils containing higher percentages of sand and gravel. The lacustrine deposits have soils with silt loam and silty clay loam textures, and very few coarse fragments.

Pre-fire condition generally supported an organic duff layer under both the forested and grassland setting. The surface layer of organic duff ranges from 1 to 3 inches in depth on most mountain slopes and ridgetops. On the wetter, northernly aspect lower elevation mountain slopes the duff depth was from 5 to 8 inches deep. The upper soil typically contains many fine plant roots. Generally, the soils are classified at the order level as either inceptisols or alfisols, with some andisols in the high elevation basins, and mollisols in the low elevation grasslands.

The fire areas include a series of landforms in the landscape from lower elevation alluvial stream or glacial outwash deposits, to moderately sloping glacial till hillslopes, to mid-elevation glacial troughwalls and mountain slopes, and ending in high elevation glacial cirque basins and alpine ridges. Table 103 and Table 104 give a general description of the landscape settings of the fire areas. Complete descriptions of the soils in the Robert and Wedge Canyon burned areas are found in the Flathead National Forest – Land System Inventory (USDA FS 1983).

Table 103. Some typical landscape characteristics (landforms, vegetation, soils) within the Robert Fire Project area.

Landforms /Vegetation	Representative Soil Sub-groups	Parent Material	Slope Range	Estimated Area (%)
Valley Bottom, OutwashTerraces / Grass/Shrub	Udifluvents Eutroboralfs	Alluvium Lacustrine	0-15%	5%
Glacial Till Deposits / Douglas Fir & Mixed Conifer	Cryoboralfs	Meta-sedimentary	25-40%	40%
Glacial Troughwalls & Structural Breaklands / Moist Subalpine Fir Forest	Cryochrepts Cryoboralfs	Meta-sedimentary	55-75%	35%
Cirque Basin & Alpine Ridges / Cold Subalpine Fir Forest	Cryoboralfs Cryochrepts Haplocryands	Meta-sedimentary	15-60%	20%

Table 104. Some typical landscape characteristics (landforms, vegetation, soils) within the Wedge Canyon Fire Project area.

Landforms /Vegetation	Representative Soil Sub-groups	Parent Material	Slope Range	Estimated Area (%)
Valley Bottom, OutwashTerraces / Grass/Shrub	Udifluvents Eutroboralfs	Alluvium Lacustrine	0-15%	5%
Glacial Till Deposits / Douglas Fir & Mixed Conifer	Cryoboralfs	Meta-sedimentary	25-40%	40%
Glacial Troughwalls & Structural Breaklands / Moist Subalpine Fir Forest	Cryochrepts Cryoboralfs	Meta-sedimentary	55-75%	25%
Cirque Basin & Alpine Ridges / Cold Subalpine Fir Forest	Cryoboralfs Cryochrepts Haplocryands	Meta-sedimentary	15-60%	30%

Disturbances such as fire and timber harvest release nutrients from vegetation and soil. Many of the nutrients end up stored in the soil where they can be used by plants. Some nutrients find their way into streams and ultimately end up in Flathead Lake, which has a total maximum daily load (TMDL) completed. The two primary nutrients of concern for Flathead Lake are nitrogen and phosphorus. The potential nutrient contribution for each individual landform is rated from low to high in the following landform descriptions. The nitrogen yield rating is based on the natural level of nitrogen in the soil, soil permeability and precipitation rate. The phosphorus yield rating is based on the natural level of phosphorus in the soil and the sediment hazard.

Another important component of these landforms are areas of sensitive soils. Sensitive soils typically have an excess of water in the soil, usually on a seasonal basis, but in some cases year around. These soils predominantly occur in the valley bottoms and are associated with riparian or wetland areas. When sensitive soils are in their natural undisturbed condition they act as temporary storage sites for water, allowing it to slowly move down slope until it reaches springs, wetlands or streams or into groundwater if the underlying bedrock is permeable. When sensitive soils are disturbed by management activities such as road building or timber harvest the water can seep out of the soil and onto the road, skid trail or landing where it moves quickly down slope. Water that would have moved slowly to a stream through the soil profile is now quickly routed to a stream. This efficient routing of water increases water yields and the risk of sediment. See Figure 33 and Figure 34, maps of sensitive soils, below.

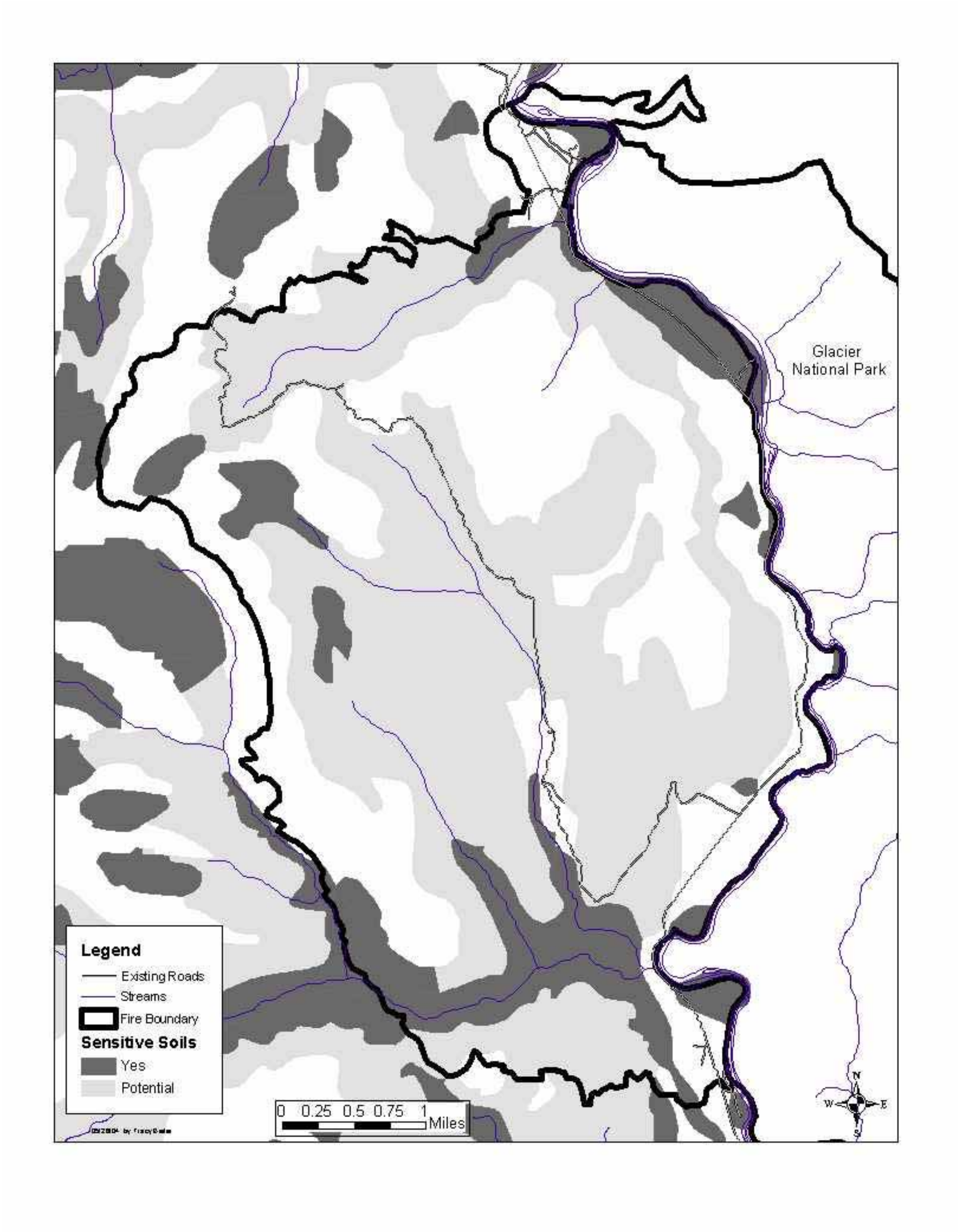

Figure 33. Sensitive Soils – Robert Fire Area

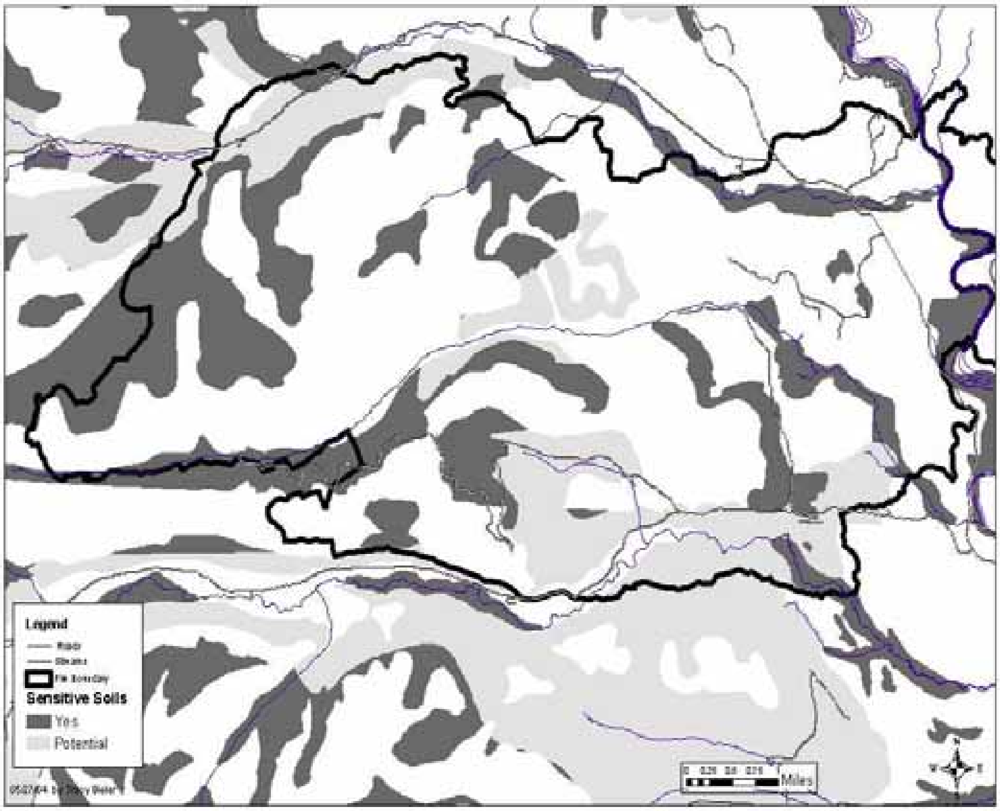

Figure 34. Sensitive Soils – Wedge Canyon Fire Area

Table 105 describes the landform groups found in the drainages within the Robert and Wedge Canyon Fires. The Project File contains a detailed discussion of the potential nutrient contribution associated with forest disturbances and the sensitive soils within each landform group.

Table 105. Landforms of the Robert and Wedge Canyon Fire Project Areas

Landform Class	Most Common Stream Type[1]	Expected Nitrogen Yield After Disturbance	Expected Phosphorous Yield After Disturbance
Valley Bottoms	C and E	Moderate	High
Breaklands	A	Moderate	High
Steep Alpine Glaciated Lands	B	Moderate	High
Gently to Moderately Sloping Glaciated Lands	A or B	Low	Moderate
Mountain Slopes and Ridges	A	Moderate	Low

[1]Stream types as described in <u>Applied River Morphology</u> (Rosgen 1996): A Streams = Gradients from 4% to 10%; characterized by straight (non-sinuous), cascading reaches, with frequently spaced pools. B Streams = moderately steep streams with gradients from 2% to 4%; usually occupy narrow valleys with gently sloping sides. C Streams = low gradient systems (<2%), with moderate to high sinuosity and low to moderate confinement.

The riparian landtype inventory of the Flathead National Forest (USDA FS 1995A) is a mapped inventory and description of the riparian and wetland areas, on the non-wilderness lands of the Flathead National Forest. The map unit descriptions include discussions of the riparian/wetland landscape settings, landforms, soils, vegetation, and stream characteristics. In the Robert and Wedge Canyon post-fire project areas there are approximately 7,120 acres of riparian/wetland landtypes. Approximately 50% of those lands experienced a high soil burn severity, 20% a moderate soil burn severity, and 30% at a low soil burn severity or unburned. Refer to Project File for a map of the riparian landtypes in the project area**.** Approximately 47 acres of the 7,120 (0.6%) are proposed for harvest with this project

Previous, current, and future Land Use Activities

Robert Fire Project Area

Past Activity: Timber harvest has taken place in the Robert Fire Project Area since 1946, including precommercial thinning and reforestation. Fire suppression began in 1910. Approximately 50% percent of the fire area on National Forest System (NFS) lands has been harvested in the past (this includes all ranges of cuts from light partial cuts to clear cuts). The most recent timber activity occurred in 1993.

Road construction began in the project area in the 1920s with the construction of the North Fork Flathead main road. Road reconstruction and maintenance has been ongoing since that time. Personal use firewood cutting, Christmas tree harvesting, post and pole, and bough collection has been allowed in the project area in the recent past.

The Robert Fire suppression activity created approximately 26 miles of fire line. Of the fire line construction, approximately 2 miles were hand line and 24 miles were constructed with mechanized equipment. Approximately 158,232 gallons of fire retardant was dropped with air tankers between mid-August and late September to assist fire suppression activity. All 26 miles of fire line were rehabilitated after fire suppression activities were completed.

Trees adjacent to roads within the Robert Fire area that were identified as a hazard to firefighters and the public were felled during fire suppression actions. Removal of these trees began in the winter of 2003-2004 and will continue into the summer of 2004.

Robert Fire Burned Area Emergency Response (BAER) projects were initially implemented within the Robert Fire in the Fall of 2003. These projects included: grass seeding on erosive hill slopes, hazard tree felling in the Great Northern Flats area, replacement and upgrading of 5 culverts, stabilization of 2 culvert inlets and outlets of culverts, installation of 8 new culverts, removal of 1 culvert, cleaning of existing culverts, and improvement of road and trail drainage by implementing rolling dips and water bars.

Small amounts of private lands have been cleared, logged, and developed in areas adjacent to the North Fork Road. In addition, Stoltze Land and Lumber Company has logged portions of private land in the lower reaches of the McGinnis Creek drainage.

Current and Reasonably Foreseeable Actions: A Best Management Practices (BMPs) Project is planned for the Robert Fire Area. (as well as the other fire areas on the Forest). Roads and culverts throughout the fire area will require drainage improvement to accommodate elevated levels of run-off anticipated from the fire. Activities will begin in the summer 2004 and will likely continue for the next 2 years. This road maintenance work, which includes roads planned for timber hauling associated with proposed Robert Wedge Timber Salvage Sale, is addressed in the *Burned Areas Road Maintenance Project*. This project refers to a program of road maintenance activity to apply BMPs on up to 328 miles of forest road in or near areas that were burned by wildfire during 2003. Approximately 50 miles of roads will be maintained in or adjacent to the Robert Fire. Types of road maintenance work will include:

- Maintenance of road drainage structures including cross drains
- Brushing
- Maintenance of fill slopes, cut slopes, and ditches
- Maintenance of roadway surfaces
- Maintenance of bridges and culverts
- Removal of culverts
- Replacement of undersized culverts
- Upgrading or removing structures to provide for fish passage
- Installation of additional road drainage features including rolling dips

The last road maintenance occurred during the Robert Fire event in the summer of 2003. Forest budget constraints will limit road maintenance in the Robert Project Area in the foreseeable future. Maintenance will occur as funds become available. These actions would include road blading and culvert cleaning when and where necessary.

Recreational public uses such as sightseeing, hiking, camping and snowmobiling are expected to continue. It is estimated that recreational use within the project area will increase over the next 10 years.

Currently, a closure order for firewood cutting exists within the fire area. The closure order will be rescinded after harvest activities are completed. The closure will remain in effect for all riparian areas until further notice.

Wedge Canyon Fire Project Area

Past Activity: Timber harvest has taken place in the Wedge Canyon fire area since 1951, including precommercial thinning and reforestation. Fire suppression began in 1910. Approximately 32% percent of the fire area on NFS lands has been harvested (this includes all ranges of cuts from light partial cuts to clear cuts). The most recent timber sale analysis occurred in the Hornet Wedge Project where 588 acres were harvested from 1998 to 2002.

Road construction began with the construction of the North Fork Road. The northern stretches of the road were constructed in 1921. After World War II, the Forest Service began to maintain the North Fork Road for logging purposes. Road reconstruction and maintenance has been ongoing since that time. Like the Robert Fire Project Area, personal use firewood cutting, Christmas tree harvesting, post and pole, and bough collection has been allowed in the project area in the recent past.

The Wedge Canyon Fire suppression activity created approximately 53 miles of fire line. Of the fire line construction, approximately 19 miles were hand line and 34 miles were constructed with mechanized equipment. Approximately 85,362 gallons of fire retardant was dropped with air tankers between mid-August and late September to assist fire suppression activity. All 53 miles of fire line were rehabilitated after fire suppression activities were completed.

Trees adjacent to roads within the Wedge Canyon Fire area that were identified as a hazard to firefighters and the public were felled during fire suppression actions. Removal of these trees began in the winter of 2003-2004 and will continue into the summer of 2004.

Wedge Canyon Fire BAER projects were initially implemented within the Wedge Canyon Fire in the Fall of 2003. These projects included grass seeding and straw mulching on erosive hill slopes, stabilizing culvert inlets and outlets, cleaning of existing culverts, installing drainage on roads and trails, and repairing a bridge. BAER work will continue during the summer and fall of 2004.

Small amounts of private lands have been cleared, logged, and developed (primarily in the Tepee Lake Area).

Current and Reasonably Foreseeable Actions: The Montana Department of Natural Resources and Conservation (DNRC) is currently logging Section 16. Approximately 197 acres were tractor logged during the winter of 2003-2004. An additional 30 acres will be skyline logged by the end of this summer (2004).

A Best Management Practices (BMPs) Project is planned for all the 2003 fires including the Wedge Canyon Fire Area in conjunction with the Robert Fire BMP Project. Roads and culverts throughout the fire area will require drainage improvement to accommodate elevated levels of run-off anticipated from the fire. Like the Robert Project Area, activities will begin in the summer 2004 and will likely continue for the next 2 years. Approximately 38 miles of roads will be maintained in or adjacent to the Wedge Canyon Fire. Types of road maintenance work will include:

- Maintenance of road drainage structures including cross drains
- Brushing
- Maintenance of fill slopes, cut slopes, and ditches
- Maintenance of roadway surfaces
- Maintenance of bridges and culverts
- Removal of culverts
- Replacement of undersized culverts
- Upgrading or removing structures to provide for fish passage
- Installation of additional road drainage features including rolling dips

Tree plantings will be conducted on sensitive soils in the project area in the next several years.

Like the Robert fire, road maintenance occurred in the Wedge Canyon Fire Project Area the summer of 2003. Like the Robert Fire Project Area, annual maintenance will not occur in the project area in the near future due to Forest budget constraints. When funds become available in the future, routine maintenance will occur. These actions would include road blading and culvert cleaning where and when necessary. The Trail Creek Road Slump repair is expected to be worked on this summer (2004) with BAER funds. Two roads (Forest Roads 1672 and 5234) will be decommissioned this summer (2004) through the Hornet Wedge Decision Notice. In addition, Forest Road 1671 will be bermed.

Recreational public uses such as sightseeing, hiking, camping and snowmobiling are expected to continue. It is estimated that recreational use within the project area will increase over the next 10 years.

Currently, a closure order for firewood cutting exists within the fire area. The closure order will be rescinded after harvest activities are completed. The closure will remain in effect for all riparian areas until further notice.

Pre Fire and Post Fire Watershed Assessment

As part of the effects analysis, both the Robert and Wedge Canyon Project Areas were divided into six watershed analysis areas for a total of twelve individual watershed analysis areas. Ten of these watershed analysis areas are true watersheds and/or basins, where the entire land area that collects and concentrates water is included in the watershed analysis area. Two of the watershed analysis areas are the assemblage of streams that flow directly into the North Fork of the Flathead River from the stream terrace or the break land landforms directly above the creek. These are called face drainages and are typically 1st order streams. The analysis watersheds are labeled with either the primary stream name, or the primary stream they are tributary to. Refer to Figure 35 and Figure 36 for the delineations of the analysis watersheds.

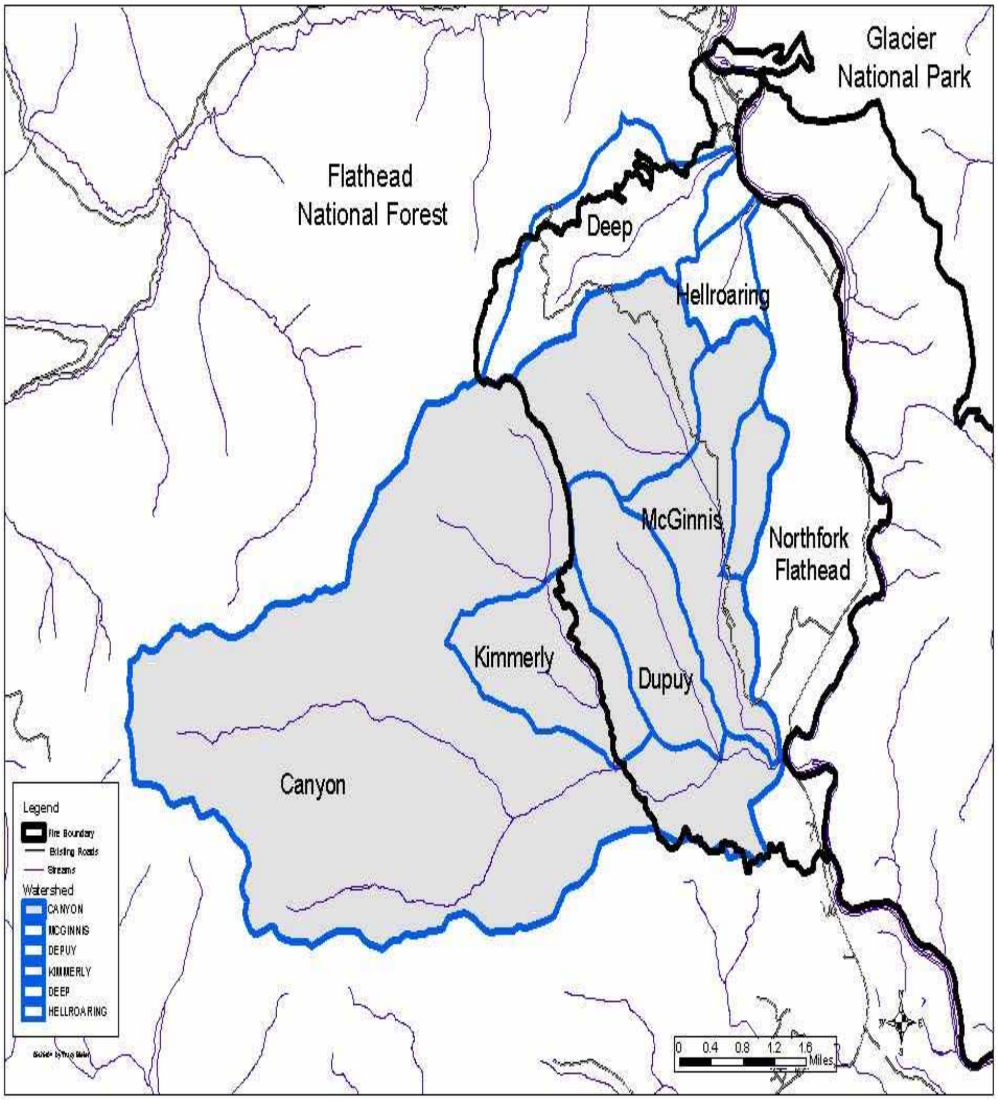

Figure 35. Watershed Analysis Area – Robert Fire Area

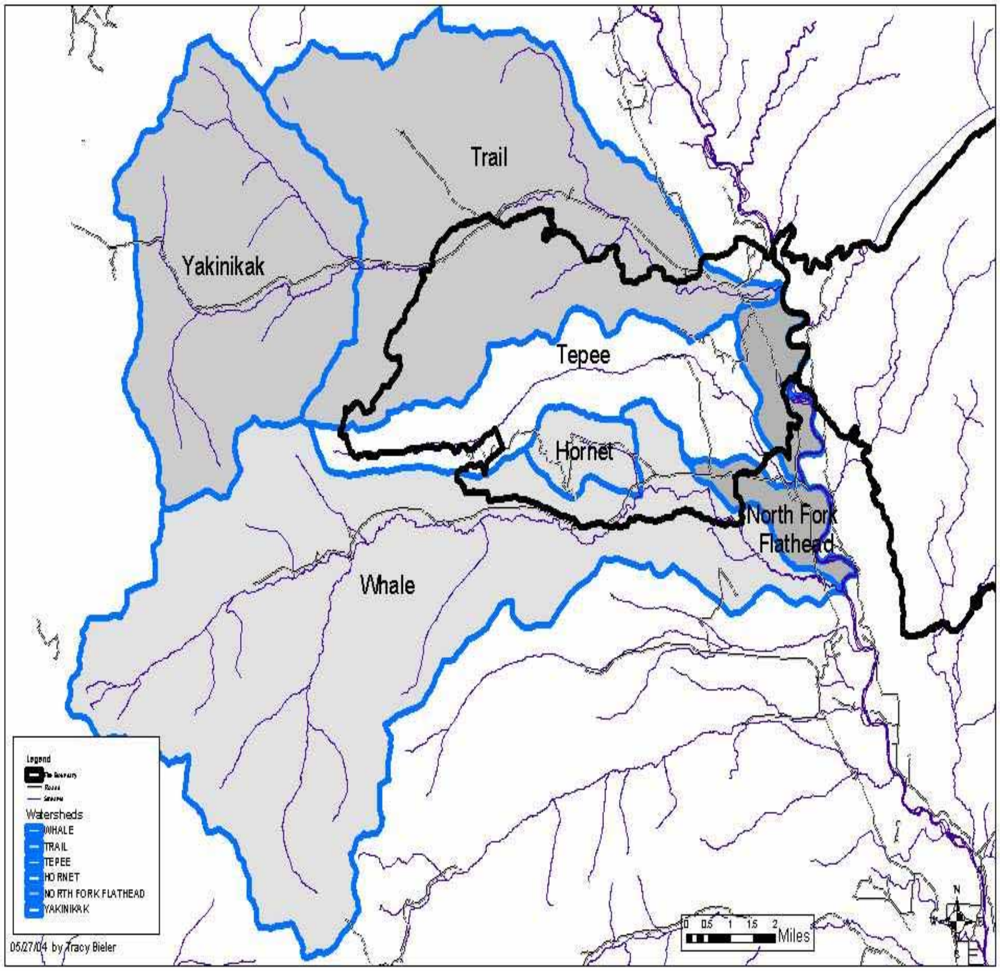

Figure 36. Watershed Analysis Area –Wedge Canyon Fire Area

Table 106 and Table 107 summarize the road system within the Robert and Wedge Canyon Fire Areas by analysis watershed. There are numerous road crossings of the stream network and areas where roads infringe upon riparian habitat. Areas where roads infringe upon riparian habitat in include: Upper Canyon Creek and lower portions of Kimmerly and South Fork Canyon Creeks within the Robert Fire project area and the main stems of Shorty, Yakinikak, Thoma, and Upper Tepee as well as isolated reaches of Whale Creek within the Wedge Canyon Project Area.

The tables also summarize the percent of each analysis watershed that has some type of timber management activity. This is a characterization of the amount of ground disturbing activities in each watershed. The tables also summarizes the existing percentage of each analysis watershed that is in Equivalent Clearcut Area (ECA). This is a characterization of the amount of the watershed that additional water yield can result from.

Table 106. The Robert Post-fire Project analysis watersheds, their size, total miles of existing roads, road density, percentage of each watershed harvested based upon equivalent clearcut area, percentage of each watershed consumed by the fire based upon equivalent clearcut area and the modeled natural and existing water yields.

Analysis Watershed	Area (acres)	Total Roads (mi)	Road Density (mi./mi.^{2})	ECA Adjusted Watershed Harvest (%)[1]	ECA Adjusted Watershed Burn (%)	Annual Natural Water Yield (acre-feet)	1st year Post-fire Water Yield (acre-feet)
Hell Roaring Creek	505	1.0	1.3	0	78	552	726
Deep Creek	1,862	11.6	4.0	0	73	2,548	3,220
Kimmerly Creek	4,287	16.4	2.4	13	10	8,984	9,351
McGinnis Creek	4,193	4.0	4.0	0	94	5,619	7,804
Canyon Creek	19,041	83.3	2.8	16	36	31,347	35,477
Hell Roaring, Deep Creek, and North Face drainages	5,857	31.9	3.5	0	81	8,038	9,866

[1]This is the percentage of the watershed that has had any type of timber management activities including: clearcut, shelterwood harvest, seed tree harvest, salvage harvest, and commercial thinning.

Table 107. The Wedge Canyon Post-fire Project analysis watersheds, their size, total miles of existing roads, road density, percentage of each watershed harvested based upon equivalent clearcut area, percentage of each watershed consumed by the fire based upon equivalent clearcut area and the modeled natural and existing water yields.

Analysis Watershed	Area (acres)	Total Roads (mi)	Road Density (mi./mi.^{2})	ECA Adjusted Watershed Harvest (%)[1]	ECA Adjusted Watershed Burn (%)	Annual Natural Water Yield (acre-feet)	1st year Post-fire Water Yield (acre-feet)
Tepee Creek	9,512	42.7	2.9	3	72	19,189	23,305
Whale Creek	40,959	80.3	1.3	14	11	106,488	110,561
Hornet Creek	1,827	11.9	4.2	0	91	3,527	4,683
Trail/Yakinikak Creeks	45,233	41.6	0.6	2	16	108,221	114,397
Cleft Creek	1,723	0	0	0	65	4,532	5,271
North Fork Face drainages	3,889	16.5	2.7	4	45	2,337	2,809

[1]This is the percentage of the watershed that has had any type of timber management activities including: clearcut, shelterwood harvest, seed tree harvest, salvage harvest, and commercial thinning.

In the late 1950's, 1960's, and 1970's, both the Robert and Wedge Canyon Project areas experienced extensive spruce beetle outbreaks. Timber harvest occurred to combat these outbreaks. In the 1960's and 70's the construction of roads and logging skid trail networks associated with these timber harvests on both national forest system and private lands caused an increased sediment load to streams within the project areas. At the same time, there was an increase in water yield following the extensive timber harvest on national forest system and private lands. During the late 1970's and early 80's this increased water yield, in combination with the excess sediment supply, caused streambank instability and stream channel erosion. This resulted in stream channel widening and stream pool filling from bedload sediments that could not be transported by the stream. Where the gradient of project area streams is low, particularly in the stretches with less than 4 percent slope, large quantities of sediments were deposited as point and mid-channel bars found upstream from organic debris in the streams such as individual logs or log jams.

Where management activities have been light or nonexistent in the project areas, stream channels are not eroding; rocks in the channels are covered with moss and algae, indicating low erosion. Since the major management activities (specifically in Whale Creek) in the 1960s and 1970s, general stream conditions are gradually improving due to natural revegetation recovery and artificial rehabilitation. However, additional rehabilitation can hasten the return of the impaired portions of Whale Creek within the Wedge Canyon Project Area.

Stream Condition Surveys in the Robert and Wedge Canyon Project Areas

Pfankuch Stream Channel Rating

The Pfankuch stream channel rating was developed to "systemize measurements and evaluations of the resistive capacity of mountain stream channels to the detachment of bed and bank materials and to provide information about the capacity of streams to adjust and recover from potential changes in flow and/or increases in sediment production" (USDA FS, 1978). This procedure uses a qualitative measurement with associated mathematical values to reflect stream conditions. The rating is based on 15 categories: six related to the bottom of the stream channel (the part of the channel covered by water yearlong), five related to the lower banks (covered by water only during spring runoff), and four related to the upper banks (covered by water only during flood stages). Streams rated *excellent (<38) or good (39-76)* are less likely to erode during high flow than streams in *fair (77-114)* or *poor (115+)* condition. Prime fish habitat usually occurs in streams with a *good* or *fair* rating; streams in *excellent* condition usually do not have adequate gravels for good spawning habitat.

The rating is evaluated at a spot or reach of stream. Each rating represents one point in time; therefore, a series of ratings must be made over several years to show the trend of stream stability. This method shows whether the stream is headed towards or away from dynamic equilibrium.

In the late 1970s and early 1980s, stream channels were sampled at selected sites in Canyon, Deep, Kimmerly, McGinnis and Depuy Creeks within the Robert Fire Project Area and Hornet, Tepee, Whale, Shorty, Ninko, Koopee, Inuya, Trail, and Yakinikak Creeks within the Wedge Canyon Fire Project Area. Sites within Tepee, Trail, Hornet, Whale, Canyon, Depuy, Kimmerly, and McGinnis Creeks were surveyed after the fires in the fall of 2003 to assess how streams would handle post fire stream flow. Sites in Whale Creek were also surveyed in 2003 just before the Wedge Canyon Fire to support the ongoing TMDL development. These ratings were not intended to reflect any changes to the streams due to the fire (not enough time for the fire to influence sediment and other changes). Rather, these ratings were done to compare the expected change in stream conditions following post-fire runoff events. In many cases, the lower elevation reaches were surveyed because they typically had the largest amount of burn area above them, and are the most sensitive to sediment increases. All ratings from the 1970's to 1980's for both fires fell into the *fair* to *good* category. Ratings from 2003 monitoring for the Robert Fire Project Area included ratings of *good* for Canyon Creek (71 and 72), *good* for Depuy Creek (75), *fair* for Kimmerly Creek (94) and poor for McGinnis Creek (119). The McGinnis Creek rating is primarily due to naturally occurring unstable terrace landforms. Ratings from 2003 monitoring for the Wedge Canyon Fire Project Area included *good* to *fair* for Tepee Creek (67,69, 71, 73, 75, and 89), *fair* for Trail Creek (67), *fair* to *good* for Whale Creek (in between 60 and 85) and *fair* for Hornet Creek (95). Detailed results of all Pfankuch surveys can be found in the Project File.

McNeil Core Sediment Measurements

The size range of streambed materials is indicative of the quality of fish spawning and incubation habitat. Increased fine sediments reduce pool depth, fill the interstitial spaces needed for invertebrate production, and reduce embryonic survival of fry (Weaver and Fraley 1991). A McNeil corer (McNeil and Ahnell 1964) is used to collect streambed samples which are dried and sieve analyzed to determine the particle size distribution, and percentage of materials less than 6.5mm in diameter (fines). As part of the Flathead Basin Forest Practices - Water Quality, and Fisheries Cooperative Research Program, Fraley and Weaver established a correlation between the streambed fines and the bull trout survival in the Flathead River Basin. A statistically significant correlation was identified, that streambed fines greater than 35% resulted in decreased survival of bull trout (Weaver and Fraley 1991). Streams that have greater than 35% fines are considered *threatened* while streams with greater than 40% fines are considered *impaired*.

McNeil core samples have been taken in Whale and Trail Creeks since 1981. No McNeil Core Samples have been taken within the Robert Fire Project Area. Table 108 reports the results of the McNeil core monitoring program for Whale Creek while Table 109 reports McNeil core monitoring program results for Trail Creek. Results have remained in the high 20 percent to low 30 percent range for Whale Creek since 1989. Results for Trail Creek have remained in the high 20 percent to low 30 percent range since 1982. Whale Creek has exceeded 35 percent fines in 1988 and 1989 while Trail Creek exceeded 35 percent fines in 1982. Whale Creek is listed on the State of Montana 303(d) List for sediment due to high fines and low Bull Trout population numbers. From this data, percent fines look to be stable over the past 10 years.

Table 108. McNeil Core samples (%fine sediment <6.4mm) in Whale Creek.

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
%< 6.4mm	25.1	31.8	32.6	29.5	22.5	26.0	28.9	37.2	35.3	---
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
%< 6.4mm	34.2	32.2	33.4	29.5	32.6	31.4	30.9	31.3	31.9	30.8
Year	**2001**	**2002**								
%< 6.4mm	31.6	30.9								

Table 109. McNeil Core samples (%fine sediment <6.4mm) in Trail Creek.

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
%< 6.4mm	25.7	36.1	27.2	28.1	26.2	25.0	27.4	30.0	---	34.6
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
%< 6.4mm	33.7	29.5	33.6	24.8	29.5	34.5	29.8	30.2	30.0	29.7
Year	**2001**	**2002**								
%< 6.4mm	30.4	29.6								

Note: samples for year 2003 have been gathered but the data was unavailable to the author because the laboratory results from Montana Fish, Wildlife and Park have not been reported to us by the time of the DEIS.

Non-point Pollution Source Inventory

Field examination, qualitative, and quantitative stream monitoring confirm that the source of sediment in the Robert and Wedge Canyon Project Areas is from a combination of natural and man-caused upland and stream channel erosion. The following is a short narrative description of the current upland and in-stream sediment sources in the areas. Most of the major sediment sources have had, or are planned to have erosion control work done to them as a part of the Robert and Wedge BMP Project and ongoing fire restoration activities.

Skid Trail Rehabilitation: Skid trails to remove logs from cutting units were developed by cats and skidders during past timber harvest activities. Most of the skid trails developed in the past 20 years were water-barred when the skidding was completed. The placing of water-bars disperses the water before it is concentrated into a defined flow that causes erosion. Some of the earlier skid trails (both national forest and previously private lands) and/or the log landings have had very small streams (*skid-streams*) develop on them due to soil compaction and intercepted groundwater. These small skid-streams typically only run water during snowmelt or high intensity rainstorms, however, this does increase the peak flow response within the basin. The majority of these skid-streams have eroded away the fine textured soils within their stream bottoms and bank, causing them to be well armored by cobbles and stones, and typically well vegetated. Going back and constructing water-bars at this time would disturb the established vegetation and expose soil to be potentially eroded.

Upland Sediment Source Rehabilitation Placement: Within the project areas, there are several upland sites that are sediment sources to the streams. Most of these sites occur on moderately sloping to steep silty glacial till soils. When exposed, these soils can produce significant amounts of suspended sediment. These upland erosion sites include old landings, skid trails, and some natural or road associated mass failures. Following both the Robert and Wedge Canyon fires, additional upland erosion sites may become apparent following runoff events. These sediment sources will be reviewed for rehabilitation actions using BAER funds.

In-Channel Large Woody Debris: Prior to the 1990's and the implementation of the Montana Best Management Practices for Forestry and the Streamside Management Zone law, past timber harvest activities have included harvesting trees within riparian zones, or upland areas adjacent to riparian zones within one tree length of the stream. In some areas, this removal of trees has reduced the amount of large woody debris for current and/or future use in the stream channels. The large woody debris acts to reduce streamflow energy, trap sediments, and create pool habitat. In some areas, this reduction of large woody debris in the stream has increased the amount of bank erosion. Project design measures for this project will protect currently functioning and recovering riparian zone that provide Large Woody Debris.

Log Jam Stabilization: Log Jams occur throughout the project areas. In some cases, these jams are causing streams to erode a new channel. The removal of portions of the log jams, in some cases, would in the short-term reduce the amount of channel erosion. However, there is sediment trapped behind these log jams. Therefore, the removal of the any woody materials from these log jams would be done in a manner to minimize any movement of the trapped sediments.

Road Decommissioning: Beginning in the early 1980s road closures and road decommissioning was initiated primarily in order to improve wildlife habitat. However, there are long-term watershed improvements realized from these road management actions. Currently there are approximately 55 miles of year-around road closures in the Robert Project Area and 50 miles of year-around road closures within the Wedge Canyon Project Area. The Robert-Wedge Canyon Salvage Project proposes to decommission 14.4 miles of road-all within the Robert Project Area.

Road Drainage Improvements - BMP implementation: There are segments of the existing road system that are to remain in use, which need improvements in the road surface drainage and stream drainage systems to meet current Montana State Best Management Practices and INFISH standards. These improvements are a foreseeable action addressed in another NEPA document. The work activities include up-sizing culverts and adding more road cross-drains (culverts or drive thru dips). A spreadsheet with road numbers that need the work can be found in the Project File. This represents approximately 50 miles of roads within and just outside of the Robert Project Area and 38 miles within and just outside of the Wedge Canyon Project Area. These improvement projects will begin in the summer of 2004 and will continue over the next 2 years.

Sedimentation Effects to Water Quality

The amount of sediment routed to or eroded within a stream channel can affect the beneficial uses of water, and is frequently used as a measure of overall water quality. As stream channel size and shape have evolved to carry the historical sediment load, large increases in sediment yielded to a stream may exceed the stream's ability to transport the load (Dunne and Leopold 1978). As a result, sediment deposition will occur in the stream channel, especially in low-gradient sections of a stream, as point bars and mid-channel bars. This leads to a wider, shallower, less stable channel than pre-deposition conditions, and can have a detrimental effect to the fisheries resource by clogging spawning gravels. Increased sedimentation also impacts macro-invertebrates and other aquatic organisms. Bank erosion may also be increased, thus adding even more sediment to the load in the stream.

In managed forested areas, the main source of direct sediment is from road construction associated with timber harvest (Megahan and Kidd 1972). Channel alteration, road or other construction in or adjacent to live streams, and culvert or bridge installation may result in sediment being deposited directly into a stream. Tree felling is not usually considered a major cause of increased sediment. However, methods for removing harvested timber (such as tractor and cable yarding) can cause erosion, gouging of slopes, and alteration of soil characteristics and permeability.

Effects to Sediment Yield in Post-fire Situations

A wildfire has the potential to impact the soil to the limits of natural variability, including reduced soil aggregate stability, reduced permeability, increased runoff and erosion, and reduced organic matter/nutrient status. These combined effects will cause the runoff following a rain event to increase significantly, increasing the overland flow available to initiate soil erosion, either as sheet or rill erosion. The potential for erosion is highest on the steeper slopes that burned with a high soil burn severity[1]**.** Burn severity describes the effects of the fire on the soil hydrologic function (amount of surface litter, erodibility, infiltration rate, runoff response) and productivity. Generally there is a close correlation between these soil properties and the amount of heat experienced by the soil as well as the residence time of the heat in contact with the soil. Erosion potential can increase with salvage logging in some situations. The erosion potential decreases over time as the soil surface is revegetated and the soil aggregate stability is reestablished.

After the large fires in Yellowstone National Park during 1988, research was done on sediment increases following the fire. The largest post-fire sediment increases (load/volume runoff) occurred during the snowmelt period (April, May, June); the post-fire sediment increase ranged from 156% in April to 42% in June on the Yellowstone River (Ewing 1996). The spring runoff suspended sediment increase averaged 60% for a four-year period. There was one reported 100% increase in August (thunderstorm event) on a load per unit runoff basis. The summer season sediment increase averaged 30% for the rising streamflow period in the summer, and 7% for the falling streamflow period (Ibid. 1996).

Ewing (1996) also reported a statistically significant increase in the measured total sediment discharge and the measured sediment concentration in the Yellowstone River. He also concluded that increased suspended sediment loads during snowmelt were small in comparison to post-fire summer events. Ewing stated, "the largest portion of the fire-related sediment is transported out of the burned watersheds during the highest runoff of the year. As burned sites revegetated and erosion diminishes, fine sediment may thus be progressively transported downriver by spring runoffs."

In the Entiat Experimental Forest of central Washington state, there were sediment increases of 8 to 10 times pre-fire levels in three 1.8 to 2.1 square mile watersheds (Helvey 1980).

The spring following the 1988 Red Bench Fire in the North Fork of the Flathead River just north of the Robert and south of the Wedge Canyon Fire area, total suspended solids (TSS) experienced 2 to 3 fold increases on Flathead National Forest system lands and 5 to 10 fold increases on the Glacier National Park lands. In the burned watersheds, the TSS decreased after the first year but remained slightly higher throughout the five-year duration of the study (Hauer and Spenser 1998).

Locally, a study was done to measure the effects of logging and then prescribed fire on the soils in the Miller Creek area of the Flathead National Forest. DeByle and Packer (1972) reported that two or more times the overland flow was observed on the logged and burned plots versus the control plots. There was virtually no soil erosion on the un-logged control plots, while on logged and burned plots erosion averaged 56 pounds per acre the first year following treatment; and 168 pounds per acre the second year following treatment. This run-off and erosion was attributed to reduced vegetative cover. The organic matter content of the sediments ranged from 12 to 44 percent in the treated plots. They noted that the overland flow and erosion from the logging/fire treatments versus the control should be the same by the fifth or sixth year.

[1]The term 'soil burn severity' is used as a relative measure of the degree of change in a watershed that relates to the severity of the effects of the fire on the topsoil and the associated watershed conditions. Soil burn severity is delineated on topographic maps as polygons labeled high, moderate, and low. On low soil burn severity sites, the duff layer is typically only partially consumed by the fire and/or there is very little

heating of the soil surface layer. The fire has not affected the soil hydrologic properties. Many unburned small roots are prevalent immediately below the soil surface, the mineral composition provided a degree of insulation that protected shallow fine roots and embedded seeds. Natural re-vegetation on these is typically very good. On the high soil burn severity sites, the surface soil properties have been modified by the fire. In many of these sites, the surface soil structure has been broken down, and at the same time a hydrophobic layer (water repellent) may be established during the fire. The surface soil aggregate stability has been significantly reduced. Many of the soils once had moderate to fine granular soil peds in the surface layer. Now the surface soil has very few intact soil peds, the soil surface is essentially structureless (single grain). The lack of surface soil structure and lack of organic litter or duff allows for rain-impact erosion at the soil-air interface, reduced infiltration, and increase erosion and runoff. There are few viable roots/seeds in the upper several inches of the soil. The natural re-vegetation on these sites is typically very slow.

The moderate soil burn severity sites tend to show some slight indications of the surface soil structure break down, and a significant reduction in near surface fine root viability. Some hydrophobic soil conditions may occur under moderate burn severity sites, but it is usually quite spotty (Ryan and Noste 1983).

Sedimentation Effects from the Robert and Wedge Canyon Fires

Soils in the Robert and Wedge Canyon Fire areas under pre-fire conditions generally supported an organic duff layer. The surface layer of organic duff ranges from 1 to 4 inches in depth. The upper soil typically contains many fine plant roots, and many small pores and stable soil aggregates, which in combination facilitated rapid water infiltration and percolation. The pre-fire surface erosion rates were very low to non-existent in undisturbed portions of the watershed.

The low soil burn severity sites will naturally re-vegetate rapidly and have no/very low potential for soil erosion. Both the Robert and Wedge Canyon Fires had several large areas of moderate soil burn severity with inclusions of smaller areas of high soil burn severity within these large burned patches. Most of the moderate and high soil burn severity occurred on shrub dominated sites, which typically have good natural re-vegetation potential following wildfire. The moderate soil burn severity sites are expected to re-vegetate rapidly. However, the high soil burn severity sites initially will have less vegetation re-growth (vegetation cover) to protect the surface soil from erosion, especially when compared to the low soil burn severity areas. Refer to the soil burn severity map for the Robert and Wedge Canyon Fire areas in the Project File.

The post-fire aerial observations and follow-up ground investigations revealed that the vast majority of the moderate soil burn severity on the Flathead National Forest did not have very much potential to deliver sediment into a stream channel. The primary reasons for that interpretation are the expected natural re-vegetation response, and the general lack of expected soil erosion. This low soil erosion rate is expected from ameliorated soil hydrophobic conditions. The post-fire hydrophobic soil condition tends to ameliorate itself within 2 to 3 weeks with low intensity rain events that slowly wet the surface soil layers. (Refer to the Soils section for observations and conclusions regarding the post-fire hydrophobic soil conditions.) Under normal precipitation events we would not expect to see any severe soil erosion from the vast majority of hill-slopes in the burn area. We would expect the post-fire responses in most watersheds that had a significant percentage of their area in moderate or high soil burn severity to be the following: (1) an initial flush of ash into the creeks and (2) to some extent rill and some small gully erosion in the ephemeral drainages on the steep valley walls within the high soil burn severity. However, if intense rainstorms were to occur over the fire area significant erosion could be expected on some of the moderate and high soil burn severity sites. More than 17 tons per acre of soil erosion is estimated to occur with an intense rainstorm before all the post-fire hydrophobic soil conditions recover and the sites are revegetated.

The only area of significant upland soil erosion potential is in high soil burn severity areas, located in steep to very steep hill-slopes (50-70% slope). There are not any proposed activities in any high soil burn severity sites with steep slopes (>50%).

Additionally, the wildfires have caused a slight potential for increased sediment yield at the streambank escarpment mass failure sites and the unstable stream reaches in mid-to lower Canyon and McGinnis Creeks.

Following the Robert and Wedge Canyon Fire events, many of the stream bottoms were examined in the field and it was the interpretation of the soil scientist/vegetation specialist that the riparian shrub component was still viable and would reestablish rapidly on the majority of the burned streams. This is especially true for the flatter, low elevation main stem stream-bottoms. However, several of the steeper, deeply incised perennial and ephemeral stream bottoms within the project areas burned with high or moderate soil burn severity. In these areas the natural re-vegetation of shrubs and trees is going to be significantly reduced for several years. This makes these draws very susceptible to channel erosion and debris torrents, with the right type of storm and/or snowmelt event.

Many of the main drainages within the project areas are large Rosgen “C” channels with a well-developed floodplain and high width/depth ratios. Large woody materials are common across the floodplain, especially along the channel margins. This gives it a wide area for “storage” of products from upland or in-channel erosion. The coarser sediment from upstream should settle out in this area, leaving the finer sediment to travel downstream, and then probably only during the peak flow period.

The WEPP model was used to estimate the potential post-fire sedimentation during the post-fire assessment process. Two different situations were modeled for each soil map unit within the potential salvage area boundary: 1) Post-fire potential soil sedimentation rate (immediate post-fire) 11/1/03 thru 7/15/2004. And 2) the second growing season potential soil sedimentation rate 7/15/2004 thru 7/15/2005 with no salvage treatments applied.

The data inputted into the WEPP computer model includes the following parameters: local climate data, soil texture, treatment to the site, slope gradient, slope length, slope area, and percent cover on the site. The Flathead NF Landtype Survey (LT) was used for primary input data into the WEPP model. The slope characteristics were developed from the landtype survey report and the topographic plot of the landtype survey for each map unit in the fire area. The climate data from Bigfork, Montana (South 12 miles) NOAA station was used as the climate to model the precipitation events. The percent cover (surface rock/vegetation cover) for a given soil map unit for either the current situation or for a future scenario was based upon the best professional judgment of the soil scientist, after discussions with the vegetation specialist. The time period modeled was for 30 years; therefore the reported soil erosion rate can be expected to be the maximum probable rate associated with a 25-year return interval storm. Refer to Table 110 and Table 111 for the estimated potential sediment from the Robert and Wedge Canyon Fire burn areas using the WEPP erosion model.

Table 110. Potential Sediment Yield from Burned Lands in Robert Post-fire Area from the WEPP model for the first and second season using the 30-year average precipitation.

WEPP Potential Sediment 11/1/03 thru 7/15/2004, 30-YR Average Precipitation (tons)	WEPP Potential Sediment 7/15/2004 thru 7/15/2005, 30-YR Average Precipitation (tons)
90,343	22,541

Table 111. Potential Sediment Yield from Burned Lands in Wedge Canyon Post-fire Area from the WEPP model for the first and second season using the 30-year average precipitation.

WEPP Potential Sediment 11/1/03 thru 7/15/2004, 30-YR Average Precipitation (tons)	WEPP Potential Sediment 7/15/2004 thru 7/15/2005, 30-YR Average Precipitation (tons)
46,235	7,734

Note: Sediment Yield does not include road and landslide inputs. This will be covered in the Environmental Consequences section.

To give the reader some relative measure of soil erosion in tons, one inch of eroded soil material from one acre is approximately 200 tons of eroded soil material.

The post-fire sediment yield for the Robert and Wedge Canyon Fire Areas is entirely dependent upon weather events over the next two to three seasons until significant natural revegetation occurs. Based upon observations by the current and former Flathead National Forest soil scientists of other major fires in the ecosystem, with no major storm event the best-case scenario sediment yield from the fire areas could be substantially less than the WEPP estimation for the 1st and 2nd year post-fire sediment yield. However, if a high intensity rainstorm were to occur the WEPP estimate for the 2nd year following the wildfire is very reasonable, based upon observations by the project hydrologist and soil scientist of burn areas that have had post-fire erosion events. Also, literature of post-fire erosion events reports erosion rates comparable to the WEPP estimates (Debano et al. 1998, Sirucek 1987).

Water Quantity - Water Yield

The relationship between vegetation removal via timber harvest and water yield increases are well established (USDA FS 1976). The majority of the increase in water yield occurs during spring runoff (King 1989). Climate primarily determines the magnitude of large flood events (Dunne and Leopold 1978); however, land use practices have been shown to increase peak flows (Troendle and Kaufmann 1987). The reduction in tree density and canopy cover results in a reduction in the amount of transpiration of groundwater and also the amount of canopy interception of rainfall/snowfall which increases the amount of the precipitation available for runoff as stream flow. The amount of water yield declines as the tree canopy cover recovers. The stand types/habitat types that primarily occur in the proposed units would normally be expected to have full vegetative-hydrologic recovery in approximately 90 years after a clearcut or stand replacement fire (Northern Region 1976, Galbraith 1973).

Watersheds exhibit great natural variability in flow, and can accommodate some increase in peak flows without damage to stream channels and aquatic organisms. Increases in average high flows can cause a variety of channel effects such as increases in channel width, depth, erosion, and sediment deposition. Substantial increases in peak flows generally lead to a subsequent increase in sedimentation. If the amount of water yield increase is too much for the capacity of the stream channel, there will typically be an increase in the amount of stream channel erosion.

McCaughey and Farnes (2001) monitored snow water equivalent for seven years in a natural dense canopy lodgepole stand and in an open meadow on the Lewis and Clark National Forest. They reported that there was 23% more snow water equivalent in the open meadows. The melt rates under the canopy was 47% of that in the open meadow setting and the meadow site final melt-out was approximately 10 days earlier than the dense forest canopy site. Skidmore et al. (1994) studied snow accumulation and ablation rates on the forest floor in natural lodgepole pine forest, burned forest sites, and clearcuts, in southwestern Montana. The burned forest canopy (reduced by 90% cover) had 9 percent more snow water equivalent than the mature forest stand. There was a 57 percent increase in the ablation rate associated with the burned forest stand compared to the mature forest stand. They noted "the forest structure of the burn and of the clearcut produced similar snow accumulation and ablation responses" (Ibid 1994).

Effects on Water Yield in Post Fire Situations

Extensive literature exists indicating that streamflows increase after fires through a combination of evapo-transpiration reduction, soil-surface storage reduction, and snowmelt modification. The amount and duration of the water yield increase following timber harvest activities vary according to the size and the amount of canopy removal. Following a wildfire, the burn size and soil burn severity determine the water yield increase.

Farnes (2000) notes that "the peak flow on the Yellowstone River at Corwin Springs now occurs about two days earlier than before the fires of 1988." He also reported that the maximum daily peak flow increased 2 to 6 percent. This is a basin where approximately 25 percent of the watershed area was burned in 1988. In addition, he reported that "it appeared that removing forest canopy from the lower one-third of a watershed would advance the melt in that zone and reduce the peak runoff by moving this melt water downstream prior to the peak runoff date" and "removal of forest canopy in the middle one-third of the watershed would probably increase the peak flow as a result of increased snow accumulation and melt in the openings." Farnes et al. (2000), using the historic stream flow records for the Yellowstone and Madison Rivers prior to the 1988 Yellowstone Fires, generated modeled "non-burned" flow for the two rivers for the period 1988 to 1999 and then compared those flow values to the actual measured post-fire flow. For the Yellowstone River, their analysis showed the measured flow increased 7.1 percent more than forecast with the equation during the April through July period, it increased 1.3 percent for the August through September period, and the annual increase was 5.3 percent. For the Madison River, their analysis showed the measured flow increased 7.6 percent during the April through July period, it increased 4.9 percent for the August through March period, and the annual increase was 6.3percent.

Molnau and Dodd (1995) observed that maximum snow water equivalents occur in the heavy burned canopy conditions. They observed that "the burned tree stems remaining on this site significantly influence wind pattern and snow deposition." They also reported that the mean air temperatures were found to be higher in heavy burn sites compared to light burn sites, and the lowest in undisturbed natural forest.

Water Yield Effects from the Robert and Wedge Canyon Fires

The post-fire water yield was modeled for twelve analysis watersheds within the Robert and Wedge Canyon Fire Project Areas. Water yield increase above natural was expected due to a reduction in over-story vegetation from either historic timber management or the wildfire.

Refer to Table 112 and Table 113 for the results from R1-WATSED post-fire modeled percent water yield over natural conditions for each watershed. For the watersheds that were either partly or entirely burned, the water yield increases above natural ranges from 4 to 40 percent. In general stream channels with *fair* or *good* Pfankuch stream stability ratings are at slight risk of increased channel erosion with water yield increases of less than 10 percent over natural conditions. Depending upon the channel type and natural channel stability, water yield increases in the 10-15 percent range may cause increased channel erosion). By the time of project implementation, there is reduction in the water yield increase of <1 to 4 percent in each of the analysis watersheds due to vegetation recovery. See Project File for WATSED Results.

Table 112. Summary for the analysis watersheds in the Robert Project Area where WATSED modeled post-fire water yield increase.

Analysis Watershed	Watershed Area (acres)	Post-fire Existing Annual Water Yield Increase Above the Natural Water Yield (%)
Hell Roaring, Dry, and Deep Creeks and First Order unnamed tributaries to the NF Flathead River	6,681 acres	29
Deep Creek	1,862 acres	26
McGinnis Creek	4,192 acres	40
Kimmerly Creek	4,286 acres	5
Depuy Creek	1,443 acres	36
Canyon Creek	19,043 acres	20

Table 113. Summary for the analysis watersheds in the Wedge Canyon Project Area where WATSED modeled post-fire water yield increase.

Analysis Watershed	Watershed Area (acres)	Post-fire Existing Annual Water Yield Increase Above the Natural Water Yield (%)
Unnamed tribs. draining to the NF Flathead River within the WC Fire	4,314 acres	16
Tepee Creek	9,513 acres	22
Hornet Creek	1,827 acres	31
Whale Creek	40,991 acres	4
Cleft Creek	1,723 acres	16
Trail Ck./ Yakinikak Ck.	40,335 acres	5

This increase in water yield has the most potential to cause increases in channel erosion in some of the small tributary streams in both the Robert and Wedge Canyon Project Areas. This is due to the combination of the following: 1) burned riparian vegetation, 2) burned large woody debris within the stream channel, 3) naturally erodable streambank materials, and 4) decreased response time of streamflow following a rain event.

The BAER emergency treatments addressed the expected post-fire water flow at many road stream-crossing sites located in the moderate and high soil burn severity areas. Several culverts that were deemed undersized for the expected post-fire storm flows were up-sized. Also, several stream crossings had armored overflow dips installed in the road prism, to reduce erosion if a culvert were to plug.

Water Quality – Nutrient Levels

The best available information on the level of nutrients in the waters of the North Fork of the Flathead River is published in the Joint Water Quality and Quantity Committee Report – Flathead River International Joint Commission Study (1987). That report documents the majority of the nutrient studies done on the North Fork of the Flathead River. The report states,

> Waters of the Flathead River system contain very low amounts of the major nutrients, nitrogen and phosphorous. Autotrophic production in most lotic and lentic waters in the basin appear to be phosphorous limited, although nitrogen may not be present in sufficient quantity or in the required forms to support much productivity during late summer in some waters (Ibid, 1987).

The report further addresses the relationship between suspended sediment and nitrogen and phosphorous levels:

> Clearly, particulate forms of nitrogen and phosphorus are an order of magnitude higher when streams are in spate and carrying a large mass of suspended sediment. Standford reported a significant, positive correlation between suspended sediments solids and total phosphorus (TP) and total Kjeldahl nitrogen (TKN) at the Holt site on the Flathead River immediately upstream of the confluence with Flathead Lake. The soluble forms of phosphorus are also generally more concentrated during periods of high flow. Presumably, soluble phosphorus compounds [soluble phosphorus and soluble reactive phosphorus] are leached or desorbed from particles suspended in the water column or flushed from groundwater (Ibid, 1987).

The relationship between total phosphorous and biologically available phosphorous was further described below:

> Bio-availability was estimated by a kinetic approach, using radioactive tracers, and by algal assays (Ellis and Stanford 1986a,b,c, 1987). Both methods demonstrated that only about 10 percent of the sediment phosphorus (i.e., 10 percent of particulate P measured as total phosphorus minus soluble phosphorous) was bio-available (BAP - bio-available phosphorous). Thus, the rivers in the Flathead Basin carry a substantial load of biologically inert phosphorus during spring run-off (Ibid, 1987).

Table 114 reports the phosphorus and nitrogen summary data for the North Fork of the Flathead River at the Canadian Border, and the Flathead River near Columbia Falls, derived from the International Commission Report, 1987. Note that the Flathead River at Columbia Falls is slightly downstream of the confluence of the North, Middle, and South Forks of the Flathead River. The lower station is reported to give some perspective of the cumulative addition of nutrients from the headwaters of a basin to the pour point.

Table 114. Phosphorous and nitrogen water quality monitoring data from the North Fork of the Flathead River at the Canadian Border, and the Flathead River near Columbia Falls.

River Monitoring Site /Nutrient Parameter (milligrams/liter)	Mean	Sample Number	Minimum	Maximu m
North Fork of Flathead River at the Canadian Border				
Total Phosphorus	29.74	106	2.33	236.67
Soluble Reactive Phosphorus	1.75	47	1.00	7.90
Total Nitrogen	62.01	35	18.00	114.08
Ionic Reactive Nitrogen (nitrate, nitrite, ammonium)	20.55	38	4.00	76.94
Flathead River near Columbia Falls				
Total Phosphorous	17.31	28	2.00	151.00
Soluble Reactive Phosphorus	1.48	29	1.00	7.60
Total Nitrogen	166.70	9-29	58.20	589.00
Ionic Reactive Nitrogen (nitrite, nitrate, ammonium)	35.53	27-29	15.20	95.00

Effects to Nutrient Responses in Post Fire Situations

When a fire burns through down fuels there is an oxidation of many elements that then become available for leaching and/or aerial deposition into running or standing surface water. Also, nutrients can be transported into streams, ionically attached to soil sediments, associated with increased post-fire soil erosion. The low soil burn severity sites have virtually no effect on the soil's physical or chemical properties. During the burning process, some nutrients in the grass and duff are released into the atmosphere; however, most remain in the ash and are rapidly reabsorbed into the topsoil (DeByle 1981). In these areas of concentrated woody fuels, soils directly under them can be heated enough to cause a slight reduction of some soil nutrients (e.g. nitrogen) and the microbe populations in the surface soil layer. This can have a short-term (2-3 year) reduction in vegetation cover on these sites following the fire, which in turn lead to small amounts of surface soil erosion. However, this eroded soil material is rarely transported more than a few feet downhill. These minimal short-term reductions in site productivity should be widely spaced (<5% estimated area) in the unit following the burn. In the same study an increased potential for soil nutrient leaching into the groundwater on high soil burn severity sites occurred during major precipitation events (Packer and Williams 1976).

There is the potential with a significant storm event and the associated erosion from the burn area, that increased nutrient levels could be measured above natural background variation in the lower reaches of the project area watersheds. This relationship of post-fire increased sedimentation and nutrient levels was documented by Hauer and Spenser (1990) in 1989 for Red Meadow Creek. Because of the dilution effect when the project area watersheds flow into the North Fork of the Flathead River, any increased nutrient level would probably not be able to be measured above the natural background variation with the North Fork of the Flathead River.

Debano *et al.* (1998) reports that several investigators following wildfire have found little effect of burning on ionic cation concentrations in run-off waters. At the same time he reports that other investigators have observed increased cation concentrations in stream flow following a wildfire. Typically, cations such as Ca, Mg, and K are converted into oxides, and are deposited as ash following a wildfire. These oxides are low in solubility until they react with CO2 and are converted into bicarbonate salt (Debano et al. 1998). The surface soils in the Flathead NF are typically derived from volcanic ash. They tend to have a very high cation exchange capacity, and are naturally low in levels of bicarbonate (Flathead Country – Land System Inventory, 1983). Therefore, in general the potential for cation leaching into ground or surface waters following the fire is probably low unless a major erosion event occurs.

Within the Flathead Basin, phosphorus and nitrogen are the primary nutrients of concern that have been identified and studied in connection to timber harvest and fire activities. In the Flathead Basin the primary concern with any nutrient increase in the headwater streams is a potential for increasing the nutrient levels in Flathead Lake which will lead to increased algae growth in the lake. This was specifically addressed in the Nutrient Management Plan and Total Maximum Daily Load for Flathead Lake, Montana (Montana Department of Environmental Quality, 2001), which identifies phosphorus and nitrogen as the primary nutrients of concern in the Flathead Lake basin.

Debano *et al.* (1998) reported "studies of soil leachate show increased levels of total phosphorus due to burning, indicating accelerated mobilization of phosphorus after burning. Phosphorus concentrations in overland flow can increase as a result of burning, although these increases are not always sufficient to alter the quality of streamflow." Locally, the best study of nutrient increases following wildfire was done in the North Fork of the Flathead River following the September 1988 Red Bench Fire. Spencer and Hauer (1990, 1991) measured significant short-term increases in nutrients (nitrogen and phosphorus) in several streams following the Red Bench Fire. They stated, "based on the results from our laboratory experiments, we would expect streamwater soluble reactive phosphorus (SRP) concentrations to increase rapidly at first as labile phosphorus leached from the ash deposited in the stream, and then steadily decline as the available phosphorus source was depleted." They measured up to a 40-fold increase in SRP in Lower Akokala Creek immediately following the wildfire, which then reduced to background levels 2-3 months later. During the following spring run-off, a ten-fold increase in SRP was noted in one stream with the remaining study streams having a 2 to 6-fold increase in the SRP levels. This was reduced to 2-3 fold by the fifth year following the fire (Hauer and Spenser 1998).

Hauer and Spenser (1998) reported a 25-fold increase in ammonium was noted in two streams during the fire, but the increase declined to background levels soon after the fire was out. They also measured a 3 to 7-fold increase in nitrate concentration the following spring in burned watersheds of Glacier National Park. By the fifth year of the study the nitrate levels were within the background range. A total nitrogen (TN) increase was observed of 0.5 to 8 times background in the study streams during the first spring run-off period. By the fifth year of the study differences from background were less distinct. They observed that the highest levels of nutrient increases correlated to those areas with highest soil burn severity.

Locally, a study was done to measure the effects of logging and then prescribed fire on the soils in the Miller Creek area of the Flathead National Forest. DeByle and Packer (1972) reported that an average of 0.7 pounds/acre of phosphorus, 3.1 pounds/acre of potassium, 16.1 pounds/acre of calcium, 4.0 pounds/acre of magnesium, and 1.7 pounds/acre of sodium was lost in surface run-off and sediment from logged/prescribed burned plots more then the control plots. They noted that the cumulative four year nutrient loss represents 0.5% phosphorus, 1.1% potassium, 1.5% magnesium, and 2.1% of the sodium that occurs in the top one foot of soil. Thus it would take 50 forest rotations, using similar logging and burning treatment at the end of each rotation, to fully deplete even the available sodium supply in the surface foot through man-caused disturbances.

Increased nutrient loading associated with wildfire can stimulate primary production (e.g. algae growth). Hauer and Spenser (1998), and Gangemi (1991) described an increase in stream periphyton growth in one burned watershed in the Red Bench Fire area, compared to an unburned watershed. Hauer and Spenser (1998) reported "we did not observe noticeable increases in algae growth in our larger 3rd and 4th order study streams."

3.5.3 Environmental Consequences

The following Effects Indicators were used to focus the hydrology analysis and disclose relevant environmental effects:

- Total Potential Sediment from Proposed Salvage – Robert and Wedge Canyon Fires (tons)
- Qualitative Assessment of Nutrient Load Effects
- Estimation of Number of culverts removed and sediment produced
- Sediment Yield Increase Above Natural (tons) from Proposed Road Management and Decommissioning
- Water Yield Increase from Proposed Salvage

There are two aspects related to water resources that are vulnerable to fire and management activities: First is water quantity, and second is water quality. A change in water quantity is one environmental consequence of the wildfire, and potentially an effect of the proposed action. An increase in water yield from individual watersheds in the Robert and Wedge Canyon Fires is a concern because with an increase in water yield there is an associated increase in potential for channel erosion. Water quality is assessed by both the chemical and physical properties of the water. A change in water quality is an environmental consequence of both the wildfire and the proposed action. There are two primary possible effects to the water quality, the potential for increased sediment and for increases in nutrient content of the groundwater/surface water.

Direct and Indirect Effects Common to all Alternatives

Rain on Snow Event Risk

During the EIS scoping process for this project a concerned public asked for an analysis of risk of additional water yield from the proposed salvage during rain-on-snow (ROS) events. The U.S. Geological Survey flow records for the North Fork of the Flathead River at Glacier Rim were reviewed to determine the number of annual peak flow events tied to ROS events. There is an 80-year record for this monitoring station that was examined. All of the annual peak flow discharges occurred during spring snowmelt events, mid May thru mid June. That is not to say that spring precipitation events that coincided with the snowmelt did not increase the snowmelt rate. This was the situation that occurred in June 1964 that caused a flood event. Hauer (1991) did an analysis of historic streamflow in the North Fork of the Flathead River as compared to precipitation and temperature records. He stated the following "From this data it was concluded that, indeed the onset and rising limb of spring runoff is primarily driven by increasing temperatures." Therefore, these types of events are somewhat rare for the geographical location of the project area.

Mac Donald and Hoffman (1995) discussed the causes of peak flow ROS and rain-on-spring-snowmelt events in six basins of Northwestern Montana and Northeastern Idaho, concluding: "… there was no apparent correlation between the magnitude of peak flows and the amount of forest harvest." In 1996, the Plum Creek Timber Company employed a consultant to model ROS events in the Swan River Valley. The basins they modeled were Goat and Squeezer Creeks. This analysis estimated a 4.9 percent increase in runoff from a ROS event for a 25-year return interval storm, and 4.5 percent increase for a 100-year return interval storm. These modeled increased runoffs are the amount of increase above the level for a fully forested situation versus the current forested situation for Goat and Squeezer Creeks (Plum Creek, 1997). The amount and type of timber harvest in the lower elevations of Goat and Squeezer Creeks are qualitatively similar to the amount of harvest in the lower elevations of portions of Robert and Wedge Canyon Project Areas prior to the wildfire. Because of the reduction in canopy cover from the effects of the wildfire there is potential for increased snow deposition. Based upon these wildfire effects to the vegetation there would be an increase in the effects of a ROS event in watersheds draining the fire areas. There would also be a slight additional increase in snow deposition due to post-fire timber salvage, which could slightly increase the post-fire effects of a ROS event in project area drainages. The portion of the peak flow increase related to salvage harvest would be insignificant if a ROS event were to occur in the next few years before considerable forest regeneration growth has occurred. The additional peak flow increase could have a slight risk of increasing the amount of channel erosion during a typical ROS event in the project area.

Alternative 1 (No Action)

There are no direct effects from salvage harvest activities to the water resources in the post fire project area if the No Action alternative is implemented. This is because no ground disturbing activities would be implemented with this alternative; therefore there would be no direct effect to the water quantity or quality from a direct federal action.

There is primarily one possible direct effect to the water resource of the areas if the No action alternative is implemented. The no action alternative would possibly increase the risk of both fuel buildup and wildfire, due to increased insect potential (spruce and fir beetles) in the fire areas that could spread. Another large wildfire would increase water, sediment, and nutrient yield in the headwaters streams, possibly causing additional downstream effects in both the Robert and Wedge Canyon Project Areas. Occasionally a riparian area burns during an unplanned wildland fire. If a riparian area burns there is a short-term increase in the water temperature of the streams until the riparian vegetation re-sprouts, and grows to a sufficient height to shade portions of the stream again. Concurrently, there would be an increase in the amount of snags to become large woody debris within the stream channels.

There are no direct effects from road management activities to the water resources in the post fire project area if Alternative 1 the No Action alternative is implemented. This is because no ground disturbing activities would be implemented with this alternative; therefore there would be no direct effect to the water quantity or quality from a direct federal action.

There are primarily three possible indirect effects to the water resource of the area if the no action alternative is implemented. There would be a long-term decrease in sediment and water yield increase associated with existing roads that would be foregone if the road decommissioning proposed in the action alternative were not implemented. Also, the risk of culvert failures would increase without the road decommissioning proposed in the action alternative. With the non-implementation of the Spruce and Douglas-fir beetle pheromones traps and trap trees there would be an increased risk of some of the remaining live mature and old growth Spruce trees in the non-harvested and non-burned riparian bottoms being killed. This would increase the amount of riparian vegetation that is in an early successional stage in the Robert and Wedge Canyon Project Area riparian areas. Over time this can have effects on channel stability in some riparian valley bottom settings.

Direct and Indirect Effects to the Action Alternative

Salvage Logging

Water Yield Effects

As discussed in the water yield effects of the Affected Environment section, WATSED was used to model water yield increase in each of the analysis watersheds. The existing post-fire condition was modeled using a combination of the acreages of the unburned natural forest stands, the unburned stands with some type of timber management (i.e. crown removal), the burned natural and managed stands, and the miles of existing roads. The analysis watersheds that were either partly or entirely burned during the Robert and Wedge Canyon Fires have an estimated annual water yield increase above natural that ranges from 4 to 40%; and the unburned analysis watersheds have an estimated annual water yield increase above natural that ranges from 0.1 to 6 percent.

Again, WATSED was used to analyze any possible effect to water yield increase due to the proposed salvage in the action alternative. The acreage of a proposed salvage unit was subtracted from the burned acreage in the same watershed in order not to double account for the removal of the vegetation. The results of the annual water yield increase with the implementation of the action alternative were compared to the post-fire annual water yield increase for each of the twelve analysis watersheds where salvage is proposed. The existing annual water yield increase was reduced by the time the proposed salvage would be implemented under the action alternative. The results of this analysis showed that there was no water yield increase due to the proposed salvage harvest. There are two reasons that no increase in annual water yield is associated with the proposed salvage activity. First, there is no change in the amount of live canopy remaining from the fire-killed forest to a post-fire salvage harvest unit. Note for the purposes of the water yield modeling, 98 percent of the crown cover was assumed to be removed in the burned forest stands. This assumption was based upon extensive walk-thru field reviews (fall 2003 and in past salvage sale projects, Moose 2002) of the burned stands by silviculturists and the hydrologist. And second, there is a year and a half vegetative recovery from the time of the wildfire to the approximate time when the majority of the proposed salvage would occur. Therefore, there is some very slight vegetation recovery modeled, which reduces the water yield increase. By the estimated time of implementation of the proposed salvage in the action alternative, there is reduction in the water yield increase of <1 to 4 percent in each of the analysis watersheds due to vegetation recovery. See the Project File for WATSED Model results.

The field review of the stream channels in the project areas revealed that all the streams being affected by the proposed salvage timber harvest are in Good or Fair Pfankuch stream stability classes, with one exception, McGinnis Creek. Channels in the Good class are capable of handling more water yield increase with no major adverse effects. The channels in the Fair class are at an increased risk of channel erosion from the additional water yield. The Pfankuch stream rating for McGinnis Creek is Poor, which means that additional water yield increases could cause additional channel erosion. The Poor Pfankuch rating for McGinnis Creek is cause by naturally occurring unstable landforms in the watershed. The channel was unstable before the fire and will continue to be unstable once fire conditions return to a pre fire state. WATSED estimates that post-fire water yield in McGinnis Creek will be increased by 40%. This indicates that it is likely further erosion will take place in the McGinnis Creek channel.

Sediment Yield Effects

Following a wildfire there is an increased potential for soil erosion and associated sedimentation to occur. The increased erosion potential would increase the sedimentation rate for the basin until the vegetation cover has recovered. Refer to the WEPP analysis in the Hydrology Affected Environment section for modeled sediment increases caused by the fires.

The salvage logging of some of the burned trees in the Robert and Wedge Canyon Project Areas would slightly reduce the amount of natural vegetation cover from the grasses, forbs and shrubs that have sprouted since the fire. The yarding of the burned logs causes some ground disturbance resulting in less vegetation cover on those sites for one to two seasons than would have been present without the salvage logging. (This interpretation is based upon field observations of the soil scientist and the hydrologist.) This reduction in vegetation cover in the salvage logging units increases the potential for soil erosion. The amount of reduction in vegetation cover would depend on the yarding system. Aerial yarding with a helicopter, tractor and skyline cable logging in the winter and non winter skyline cable system would have the least disturbance/reduction in vegetation, and ground based skidding without snow cover or down fuel layer would have the most. The salvage logging would also increase the potential of wind scour in the salvage units. This would slightly decrease the snow depth and snow water equivalent in the cutting units causing a slightly dryer site until the trees and large shrubs grow to several feet in height.

The potential sediment from the action alternative was analyzed using the WEPP erosion models. The WEPP model was used to analyze the comparative differences between various conditions of alternative treatments (i.e. the amount of vegetative cover). The effect to the vegetation cover of the salvage treatments included the affects to the vegetation cover due to post-salvage slash treatment. Three different situations were modeled for each soil map unit within the potential salvage area boundary: 1) the post-fire (11/1/03 to 7/15/04) potential sedimentation rate; 2) the second growing season(7/15/04 to 7/15/05) potential sedimentation rate with no salvage treatments applied; and 3) the second growing season (7/15/04 to 7/15/05) potential sedimentation rate with the proposed salvage treatments applied.

The output from situations 2 and 3 allows a comparison of the soil erosion/sedimentation risk associated with and without a salvage treatment on a given landtype. The last step is to sum the potential sedimentation for all the proposed units on all the various landtypes, under the various treatment scenarios. For simplicity, these sedimentation estimates are reported for the first year of salvage logging when the sediment yield is the highest. The sediment yield from the salvage logging decreases to zero as vegetation recovers. The time for revegetation to occur depends on the type of yarding system. The sediment yield from helicopter logging is 0 in two years. The sediment yield from cable yarding is 0 in four years. And the sediment yield from tractor skidding is 0 in seven years. The cumulative spreadsheets can be found in the Project File. Refer to the Project File for the assumptions made for soil conditions, soil burn severity, climate, vegetation recovery rates, sediment delivery ratios, post salvage slash treatments and the revegetation rates.

The potential sedimentation from the construction of helicopter, tractor and cable landings, landslide and road inputs was modeled using WEPP – Roads and WEPP – Disturbed WEPP. Based upon observations by the district hydrologist and sale administrator there should be no sediment delivered to a stream due to the application of water treatments for dust abatement. This additional potential sediment was added into the salvage logging spreadsheet results for the action alternative. The sum of those calculations is listed in Table 115 for the Robert Fire and Table 116 for the Wedge Canyon Fire. The reader should note two situations that affect the true sediment yield from the modeled sediment yield. First, the sediment analysis used the proposed unit acreages, which are greater than the treated acres proposed within some of the units (Refer to Chapter 2 for specific unit treatments). This was done because of the difficulty of knowing exactly which areas of individual units would be left due to standards and guidelines for coarse woody debris and snags; therefore, the worst-case scenario was analyzed. The second situation is that Best Management Practices used during the logging process can significantly reduce the sediment delivery efficiency of any eroded soil material from the hillside into a stream channel. This reduction in sediment delivery is very site specific and is almost impossible to model. Therefore, model results should be considered ”worst case” estimation. Actual sediment delivery would likely be lower.

The potential erosion from the proposed salvage is significantly less than from the burned area. The action alternative is less than 1% of the year one potential sediment from both the Robert and Wedge Canyon burned areas. The action alternative is 5% of the year two potential sediment for the Robert burn area and 3% for the Wedge Canyon burn area.

Table 115. Potential Sediment Yield (WEPP model) From Robert Burned Area watersheds. Includes burned landscape impacts, landslide inputs, road inputs and Proposed Post-fire Salvage inputs (including Road/Landing Construction)

	Year 1 Post-fire Potential Erosion from Burn Area watersheds (11/1/03 to 7/15/04) (tons)	Year 2 Post-fire Potential Erosion from Burn Area watersheds (7/15/04 to 7/15/05) (tons)	Total Potential Erosion from Proposed Salvage (tons)	Year 2 Potential Sediment Delivered to streams before treatment (tons)	Additional Sediment Delivered to streams due to project Implementation (tons)
No Action	90,369	22,567	NA	5,324	NA
Action	90,369	22,567	23,700	5,324	373

Table 116. Potential Sediment Yield (WEPP model) from Wedge Canyon Burned Area watersheds. Includes burned landscape impacts, landslide inputs, road inputs and Proposed Post-fire Salvage inputs (including Road/Landing Construction)

	Year 1 Post-fire Potential Erosion from Burn Area watersheds (11/1/03 to 7/15/04) (tons)	Year 2 Post-fire Potential Erosion from Burn Area watersheds (7/15/04 to 7/15/05) (tons)	Total Potential Erosion from Proposed Salvage (tons)	Year 2 Potential Sediment Delivered to streams before treatment (tons)	Additional Sediment Delivered to streams due to project Implementation (tons)
No Action	46,446	7,774	NA	3,099	NA

	Year 1 Post-fire Potential Erosion from Burn Area watersheds (11/1/03 to 7/15/04) (tons)	Year 2 Post-fire Potential Erosion from Burn Area watersheds (7/15/04 to 7/15/05) (tons)	Total Potential Erosion from Proposed Salvage (tons)	Year 2 Potential Sediment Delivered to streams before treatment (tons)	Additional Sediment Delivered to streams due to project Implementation (tons)
Action	46,446	7,774	8,038	3,099	159

Table 117 and Table 118 illustrate potential sediment from the salvage logging activities by analysis watershed. This pinpoints watersheds with higher sediment yields following the fires and the salvage logging activity. Generally all of the tributary streams above the main-stems of Robert and Wedge Canyon Project area watersheds are sediment transporting stream types, whereas the main-stems are stream types where sediment can accumulate and possibly affect fish and aquatic habitat.

Table 117. Potential Sediment Yield increase in each Analysis Watershed (Robert Fire) of the Proposed Salvage Logging (WEPP model).

Analysis Watershed	Action Alternative Potential Sediment Yield Increase (tons)
Hellroaring Creek	47
Deep Creek	168
McGinnis Creek	520
Kimmerly Creek	14
North Fork Face drainages	159
Depuy Creek	173
Canyon Creek (includes McGinnis, Kimmerly, and Deput drainages	759

Table 118. Potential Sediment Yield increase in each Analysis Watershed (Wedge Canyon Fire) of the Proposed Salvage Logging (WEPP model).

Analysis Watershed	Action Alternative Potential Sediment Yield Increase (tons)
Trail Creek	1
Hornet Creek	107
Whale Creek	260
Tepee Creek	0
North Fork Face drainages	3

All applicable forestry BMPs would be applied during the logging operations. See Appendix C in the EIS for the listing of the appropriate project-specific BMPs and Chapter 2 Design Criteria Common to All Alternatives. Also in Appendix C is a summary of the BMP audits since 1988, with the effectiveness of each BMP to prevent sedimentation. Because all appropriate BMPs would be applied to the proposed construction activities, the action alternative meets the requirements of the Clean Water Act, the Montana Water Quality Law, and the Forest Plan.

Nutrient Yield Effects

The level of nutrients in the groundwater and the streamflow of Robert and Wedge Canyon Project Area streams will increase from pre-fire base levels to an elevated level due to the fires. Hauer and Spenser (1998) reported that the highest levels of nutrient increase correlated to those areas with high soil burn severity (refer to affected environment section for more details). Because less than half of the major named watershed areas burned, and the majority of the unburned areas are in the higher precipitation zone, nutrient increase caused by the fire should be on the lower portion of Hauer and Spenser's reported ranges for soluble reactive phosphorus (SRP) and nitrate increases.

Because of the effect of increased sedimentation and slightly decreased ground cover due to the salvage logging, there may be a slight increase in the level of nutrients (i.e. nitrogen and phosphorus) caused by the proposed salvage logging. The primary change within a salvage unit is to increase the amount of finer (smaller) limbs and trunks in contact with the ground, which can enhance their potential for nutrient leaching. The increase in nutrient levels due to the salvage logging would be small compared to the increase caused by the wildfire. The rationale for this conclusion is: First, there is some removal of biomass available for nutrient contribution with the removal of the logs (stems), and a portion of the treetops on units where slash treatments occur. Smaller limbs, twigs, and needles that have been partially or totally consumed by the wildfire, are the portions of the tree that have the most nutrients that are readily releasable following timber harvest activities (Page-Dumrose,1991). Second, the salvage logging would not significantly change the chemical and water absorption characteristics of the post-fire surface soils. Third, typically after a fire the natural process of blowdown increases the amount of limbs on the ground over time. And fourth, the amount of increase in sedimentation due to the salvage harvest is relatively small compared to the increased erosion/sedimentation from the uplands and the stream channels due to additional runoff caused by the wildfire. The nutrient levels post-fire and post-salvage harvest should be less in the Project Area drainages than what Hauer and Spenser (1998) reported for their watersheds that entirely burned with a high soil burn severity.

The potential for leaching of soil nutrients into the groundwater is slightly increased for the first 2-3 years following the fire. The probability of leaching is reduced significantly in soils with high cation exchange capacity and moderately well drained soil permeability characteristics. The majority of the soils in the proposed units is derived from glacial till and has these characteristics. There are some soils in the valley bottom landtypes where proposed units occur that have somewhat excessively drained subsoils. These sites would have a slightly greater risk of leaching nutrients; even through the topsoil has a high cation exchange will be tractor logged capacity. As mentioned above, the soil types where high soil burn severity occurred are the most susceptible to excess leaching following fire. Approximately 2,540 acres (82%) of high soil burn severity areas of the Robert Fire Project Area and 1,736 acres (64%) of high soil burn severity within the Wedge Canyon Fire Area will be treated. Of the 2,540 acres treated in the high soil burn severity units within the Robert Fire Area, 1391 acres (55%) will be helicopter logged, 490 acres (19%) will be cable logged, and 659 acres (26%) will be tractor logged. Of the 1,736 acres of high soil burn severity units treated within the Wedge Canyon Fire Area, 744 acres (43%) will be helicopter logged, 87 acres (5%) will be cable logged, 512 acres (29%) will be tractor logged, 365 acres (21%) will be over the snow tractor logging, and 28 acres (2%) will be over the snow cable logging.

The amount of potential nutrient increase from the salvage (logging and slash treatment) combined with landing construction in the action alternative would probably not be discernable from the nutrient increase due to the wildfire. The combined wildfire and post-fire salvage nutrient levels should not cause a significant increase in the periphyton (algae) growth in project area watersheds or in the North Fork of the Flathead River. Based upon the pre-fire measured mean levels of total nitrogen (.067 mg/liter in Upper Whale Creek and .129 mg/L in Lower Whale Creek) and total phosphorus (.009 mg/liter for Lower Whale Creek), a post-fire short-term ten-fold increase in the total nitrogen and total phosphorus levels should not increase the levels of those parameters in the North Fork of the Flathead River beyond their natural range of variability. This is primarily due to the significant increase in streamflow when Big Creek combines with the North Fork. The overall increase in nutrient levels should not be measurable above natural variation once Robert and Wedge Canyon Project Area watersheds combine with the North Fork of The Flathead River.

If calcium chloride or magnesium chloride solutions are used for dust abatement rather than water there maybe small immeasurable amounts of those chemicals that would reach the stream system. Typically, these solutions ionically bond to the soil materials in the road surface and are very slowly (3-5 years) weathered/leached from the road surface into the surrounding soils. If any of these chemicals were to reach project area streams they would be immeasurable versus natural background amounts of calcium, magnesium, and chloride in the water.

The overall increase in nutrient levels associated with the proposed salvage activities should not be measurable above natural variation once Robert and Wedge Canyon Project Area watersheds combine with the North Fork of the Flathead River.

The proposed fuel treatments would not have any measurable effect to the water quality, water quantity or stream channels in Robert and Wedge Canyon project area streams or the North Fork of the Flathead River.

Beschta Report

Several public comments referred to a report by a group of aquatic scientists from the northwest, making recommendations on wildfire and salvage logging, called The Beschta Report. Many of their recommendations are applicable to both the Robert and Wedge Canyon Post-Fire projects. Most of the concerns identified in the Beschta *et al.* (1995) report are addressed in the design of the various alternatives (e.g. helicopter logging, RCHA width, road decommissioning), required design features (e.g. soil skid trail requirements), or implementation of Montana Forestry Best Management Practice and The Montana Streamside Management Zone law requirements. Refer to Appendix C – Beschta.

Road Management

The Robert-Wedge Canyon Post Fire Project EIS proposes to change the road management scenario on some of the roads within the project area. The different road management categories/scenarios that are proposed in the DEIS are the following: a) restrict the season of use, b) close the road yearlong with a gate, c) close the road yearlong with a berm, or d) decommission the road. Each of these road management scenarios affects the water quality and water quantity in a slightly different way.

Roads that are gated and open seasonally may have an increased or decreased sedimentation potential when compared to a season long open road. The seasonally closed road surface is exposed to the same rain and snowmelt events to erode the surface as a yearlong open road. The amount of sedimentation depends on the drainage structures built into the road prism and the amount of maintenance the road surface and the drainage structures receive. Typically, when the roads are used and not graded rutting occurs, which usually concentrates water flow and causes increased road surface erosion and sedimentation. Usually, seasonally open roads receive less maintenance than roads that are open yearlong and therefore, in general, would have a slightly higher potential for sedimentation. However, in some situations roads that are open yearlong and receive heavy use and regular road grading can have higher sediment yields because of the input of sediment following grading, especially when the ditches are cleared out with a grader. This type of road management easily allows for periodic inspection and maintenance of culverts, ditches, and cross-drain culverts, which reduces the risk of culvert plugging/failures and associated sedimentation potential. This road management scenario does not change the water quantity delivered to a stream from the road system.

When a road is restricted year long with a gate, typically some re-vegetation of the roadbed occurs with grass and brush species in this area. The amount of the re-vegetation on the roadbed is determined by the amount of administrative road use, the type of vegetation on the site, and the soil moisture conditions in that locale. In general, this scenario results in less erosion from the road surface and ditches. However, occasionally when this category of road is used for administrative purposes rutting can occur; if the road is not maintained then increased sedimentation can result from this gated yearlong road situation. This type of road management easily allows for periodic inspection and maintenance of culverts ditches, and cross-drain culverts, which reduces the risk of culvert plugging/failures and associated sedimentation potential. This road management scenario does not change the water quantity delivered to a stream from the road system.

When a road is restricted year-long with a berm, the culverts may or may not be removed depending on whether or not the road is to remain on the forest's road system, and if any high risk culverts (prone to plugging and/or failure) are present. If a road is to remain on the road system there are no culverts removed unless a high-risk culvert is identified. This scenario allows for the monitoring and inspection of remaining culverts; however, both the monitoring and the mechanical maintenance of these culverts is made more difficult/expensive with a berm in place. Therefore, the long-term risk of culvert plugging/failure and the associated sedimentation potential is increased as compared to the road management scenarios utilizing gates. Once the road is bermed, the roadbed is allowed to re-vegetate and the potential road prism soil erosion/sedimentation is significantly reduced. This road management scenario does not change the water quantity delivered to a stream from the road system.

When a road is decommissioned the following is done: 1) the road surface has water bars installed to decrease water concentration and movement that causes soil erosion from the road surface; 2) the removal of all culverts at perennial and intermittent stream crossings to eliminate the possibility of a culvert failure; and 3) the seeding of all or portions (depending on soil type and natural vegetation type) of the roadbed to initiate re-vegetation and reduce soil erosion. The road-decommissioning scenario reduces the long-term potential for direct road associated soil erosion/sedimentation better than the other road management scenarios. (Kootenai National Forest, 1995) There are three direct effects of road decommissioning. The first effect is a short-term (usually <4 hours) sediment input during the removal of a culvert, as the fine sediments in the bottom of the streambed under the culvert are washed downstream until the streambed is naturally armored. The second effect typically occurs with the first spring peak flow event following the decommissioning. At that time there will be some erosion of the lower streambanks portion of the stream channel at the removal site. This short-term increase in sediment varies with the soil materials the culvert is in and the slope of the land at the culvert site. In general, steep slopes result in more exposed soil for erosion to occur from. Also, in general, the less the coarse fragment content, and the finer the soil texture, the more potential for soil erosion.

The timing of culvert removals and application of BMP measures can minimize the effects of road decommissioning activities. When possible, the staggering of culvert removals over more than one season in a single watershed would reduce the amount of sediment entering a stream at any given season. Following a culvert removal, the use of erosion control matting and shrub planting for streambank stabilization would reduce additional erosion and sedimentation.

The third effect of road decommissioning is that the amount of ditch-intercepted groundwater that is delivered to the stream is dramatically reduced. This is because during the decommissioning process water bars with ditch blocks are installed to intercept road-surface and ditch runoff. After the water bars are installed, only very short ditch sections directly above a stream crossing are funneling ditch water into the stream. Decreasing the amount of ditch-intercepted groundwater decreases the amount of water that flows into the stream channels during peak flow events (e.g. spring snow-melt); therefore, with less water flowing in the channel there is less stream power to cause streambank erosion.

An analysis was done to display the possible effects from a culvert removal in comparison to the effects of a culvert being plugged and a portion of the road prism being eroded. The depth of roadbed over the top of a culvert is directly proportional to the slope of the streambed at the installation site. The steeper the installation site, the more surface area exposed to erosion with either a culvert removal or a culvert failure. For this comparison, three culvert installations were analyzed; on nearly level ground, a very steep installation, and a typical moderate slope installation. Actual field measurements of culvert installations and many erosion monitoring observation measurements were used in the calculations. Three different scenarios were analyzed: 1) A culvert removal in non-erosive soil conditions, with all best management practices applied; 2) A culvert removal in erosive soil conditions, with limited best management practices applied; and 3) A culvert is plugged and the road prism directly above a culvert is eroded downstream. The surface area exposed for each scenario was calculated and then multiplied by the erosion depth to obtain a volume of eroded material.

The reader should note three conditions concerning this analysis. First, the volume of eroded material in the typical glacial till soils of this area would yield approximately 60 percent suspended sediment and 40 percent bedload sediments. Second, the scenario represented by erosion caused by a plugged culvert is conservative because none of the streambank erosion that typically occurs directly below a failed culvert was modeled; only the volume of soil materials in the eroded road prism directly over the culvert is reported. Streambank erosion in these situations is extremely variable depending on site characteristics, for that reason it was not modeled. Third, in some cases when a culvert becomes plugged, the water may go down the road some distance before eroding the road fill-slope. Again, this is an extremely variable situation and was not modeled for that reason. Refer to Table 119 for the comparison of the total volume of eroded soil material for each scenario.

Table 119. A Comparison of Total Weight/Volume of Eroded Soil Materials from a Culvert Removal Site versus a Culvert Failure and the Associated Road Prism Erosion.

Culvert Depth	Culvert Removal Best Case Scenario For Soil Erosion	Culvert Removal Worst Case Scenario For Soil Erosion	Culvert Plugged the Road Prism Above the Culvert is Eroded Away
Shallow Depth (4.1 ft.)	4.6 tons (3.1 cu. yds.)	11.0 tons (8.1 cu. yds.)	7.4 tons (5.0 cu. yds.)
Moderate Depth (6.3 ft.)	4.4 tons (2.9 cu. yds.)	13.5 tons (9.1 cu. yds.)	17.2 tons (11.5 cu. yds.)
Deep Depth (15.8 ft.)	12.5 tons (8.4 cu. yds.)	50.7 tons (34.1 cu. yds.)	202.4 tons (136.3 cu. yds.)

[1]Depth is measured from the top of the outside shoulder of the road, vertically to the bottom of the culvert.

With the implementation of the Action Alternative, there would be approximately 5.7 miles of road that is currently open yearlong changed to a more restrictive road management category; either closed/opened seasonally, closed yearlong with a gate, or closed yearlong with a berm. This change of management will not affect water yield above or below existing condition as the road prism will still be present. The reduction in use will reduce the potential for rutting and maintain the integrity of the road prism and associated road BMPs. A net reduction in road associated erosion and sedimentation could be realized because of this. On the other hand, increased road associated erosion and sedimentation could be realized if these roads are not maintained and existing culverts become plugged and fail.

Additionally, the action alternative proposes 14.4 miles of road decommissioning. There are net long-term positive effects to water quality and water quantity with the reduction of open roads when a road is decommissioned. The positive effect to water quality would be the reduced area of road surface and ditch that contributes eroded soil particles as suspended sediment to the stream systems. This reduction is accomplished when the water bars are installed on the decommissioned road. The other positive long-term effect to the water quality is the reduction in the risk of culvert failure, and the associated sediment with that event.

Road decommissioning is estimated to involve 12 culvert removals in perennial and ephemeral streams. Seven of these removals will take place within the Robert Project Area while the remaining five removals will take place within the Wedge Canyon Project Area. This estimation was determined using aerial photography and topographic maps and by Flathead National Forest Zone Hydrologist Dean Sirucek and will be field verified between the draft and final EIS. There may be some additional culvert removals needed if ephemeral streams not currently mapped are encountered. For each potential culvert removal site the culvert depth class (shallow, moderate, deep) was estimated based upon landform, slope, and knowledge of the district hydrologist. The best-case scenario culvert removal soil erosion/sediment yield from Table 119 was assumed for all the removal sites in the Robert and Wedge Canyon Project Areas, because of the soil type present there. The number of culvert removals by depth class was multiplied by the erosion rate per site to give a total potential sediment yield. See Table 120 and Table 121for the results of these calculations.

Table 120. Estimated number of culvert removals associated with the proposed road decommissioning in the Robert Fire Project Area, and the related sediment yield from this activity.

Culvert Removals (Depth)	Action Alternative	Sediment Yield (Tons)
Shallow	1	4.6
Moderate	4	17.6
Deep	2	25.0
Totals	7	47.2

Table 121. Estimated number of culvert removals associated with the proposed road decommissioning in the Wedge Canyon Fire Project Area, and the related sediment yield from this activity.

Culvert Removals (Depth)	Action Alternative	Sediment Yield (Tons)
Shallow	0	0
Moderate	5	22
Deep	0	0
Totals	5	22

In the proposed action alternative, there are 4 miles of road proposed to be open seasonally, which is 4 miles more than currently exists. As discussed earlier, open seasonally roads typically get less maintenance than open yearlong roads. This sometimes results in slightly higher road surface erosion. Therefore, in general, a 4-mile increase in the open seasonally road mileage would have a slight negative effect to water quality. There would not be a change to the water quantity situation.

In the action alternative, there are 30 less miles of road closed yearlong with a gate than the existing situation. The majority of those miles are being converted to decommissioned roads under the no action alternative. The effect of this road management change would be to decrease the water quantity delivered to a stream from the road system. Also, after the short-term sediment increase associated with road decommissioning there would be a long-term sediment yield reduction as compared to a road that is gated yearlong. The risk of culvert failure would decrease with the removal of the culverts during the decommissioning process. There are a few miles of this class that would be converted to a bermed road. This would also have the effect of slightly decreasing the sedimentation level, due to the increased vegetation on the bermed road surface.

The only other category of road management that increases in mileage under the action alternative is the restricted yearlong with a berm class. In the action alternative, there are 10 miles of road proposed to be restricted yearlong with a berm. Restricting roads yearlong with a berm greatly increases the effort and cost for periodic inspection and maintenance of any remaining culverts. The roadbed would re-vegetate at some point in time, making the road impassable to machinery unless removal of the brush takes place mechanically or naturally (i.e.-fire). Therefore, the long-term risk for culvert failure and associated sedimentation is increased. As displayed in Table 119, the volume of eroded material from a culvert plugging/failure can be very significant. The risk of culvert failure is significantly reduced when the culverts are up-sized for 100-year flow capacity and recurring monitoring and routine maintenance is done. There is no change as far as the water quantity with this change in road management.

All of the roads in the closed yearlong with a berm class are to remain on the road system, therefore no culverts in perennial and intermittent streams would be removed, as during decommissioning. Rather, an inspection of the road drainage structures would be done and any high-risk or undersized culverts would be replaced with larger culverts to meet the INFISH requirements, which is to provide for a 100–year return interval flow capacity in culverts of bull trout or west-slope cutthroat trout streams. If needed, water bars or drive-thru-dips would be installed to minimize the risk of a culvert failure diverting stream flow down the road surface, causing increased erosion/sedimentation. This road management scenario allows the road surface to re-vegetate, which significantly reduces mid-term sedimentation.

Under the action alternative, there is a long-term decrease in the annual sediment yield below the existing level, associated with the proposed road decommissioning in each of the twelve analysis watersheds where work is proposed. Therefore, the action alternative has a long-term positive effect on the sediment load to Robert and Wedge Canyon Project watersheds (3 tons/year for the Robert Project Area and 2 tons/year for the Wedge Canyon Project), as compared to the no-action alternative . The short-term (approximately 1 year) sediment yield increase from culvert removals during road decommissioning under the action alternative is 47 tons for the Robert Project area and 22 tons for the Wedge Canyon Project area .

Beetle Funnel Traps/Use of Pheromones/Trap Trees

This proposal would require the felling and removal of a limited number of live Engelmann Spruce trees. Because of the limited number of live trees to be cut and removed at a later time, there would be no measurable increase in water yield. Because of the probable locations on the landscape for the removal of the Engelmann Spruce trees, there is no risk of any measurable sediment reaching a stream from this limited yarding activity. Therefore, the proposed spruce beetle treatments would not have any measurable effect to the water quality, water quantity or stream channels in the Robert or Wedge Canyon Fire Project Areas, or the North Fork of the Flathead River.

Summary of Direct and Indirect Effects for each Alternative

Table 122 and Table 123 are summaries of the results of the issue indicators analysis, along with results of the additional effect indicators.

Table 122. Summary of the Issue Indicators and Effect Indicators for the No Action and Action Alternatives (Robert Fire Project Area)

Issue Indicators	No Action	Action
Riparian Habitat Conservation Areas	NA	Standard Widths Applied
Effect Indicators	No Action	Action
Potential 2nd Year Sediment Yield Increase	Post-fire 2nd Year Potential Sediment from Burn Area 22,567 tons	Post-fire 2nd Year (22,567 tons), Plus Salvage Sediment Increase 1,133 tons
Potential 2nd Year Sediment Yield Increase – Road Decommissioning	Post-fire 2nd Year Potential Sediment from Burn Area 22,567 tons	Post-fire 2nd Year (7,774 tons), Plus Road Decom. 47 tons
Potential Annual Sediment Reduction – Road Decommissioning	None	3 tons/year
Potential Water Yield Increase	Existing Post-fire Condition	Existing Post-fire Condition (no change)
Potential Nutrient Yield Increase	Post-fire	Slight increase Above Post-fire. No water quality effects to the North Fork of the Flathead River Highest of Alternatives

Table 123. Summary of the Issue Indicators and Effect Indicators for the No Action and Action Alternatives (Wedge Canyon Project Area)

Issue Indicators	No Action	Action
Riparian Habitat Conservation Areas	NA	Standard Widths Applied
Effect Indicators	No Action	Action
Potential 2nd Year Sediment Yield Increase	Post-fire 2nd Year Potential Sediment from Burn Area 7,774 tons	Post-fire 2nd Year (7,774 tons), Plus Salvage Sediment Increase 264 tons
Potential 2nd Year Sediment Yield Increase – Road Decommissioning	Post-fire 2nd Year Potential Sediment from Burn Area 7,774 tons	Post-fire 2nd Year (7,774), Plus Road Decom. 22 tons
Potential Annual Sediment Reduction – Road Decommissioning	None	2 tons/year
Potential Water Yield Increase	Existing Post-fire Condition	Existing Post-fire Condition (no change)
Potential Nutrient Yield Increase	Post-fire	Slight increase Above Post-fire. No water quality effects to the North Fork of the Flathead River Highest of Alternatives

Cumulative Effects

Cumulative Effects Analysis Area

As described earlier, the stream flow of the North Fork of the Flathead River is significantly greater than the flows of the watersheds draining the Robert and Wedge Canyon Fire areas. The North Fork has naturally high levels of sediments being transported downstream in the spring due to extensive erosion of glacial outwash terraces and stream terraces. The larger flow volume and velocity of the North Fork River dilutes the effect of any additional input from Robert and Wedge Canyon watersheds very soon below their confluences. Many of the nutrients that are of concern bond to the suspended soil particles, some of which are deposited within the stream channels and floodplains downstream of the project areas. Therefore, there is a reduction in nutrient transport from project area watersheds as the waters move downstream. For these reasons there is virtually no statistically significant or measurable effect of any proposed management activity to water quality or water quantity, once project area watersheds combine with the North Fork of the Flathead River. Because of that situation the cumulative effects areas that were used for this analysis are all watersheds that drain either the Robert and Wedge Canyon Fire areas and terminate at the confluence point with the North Fork of the Flathead River.

Past Actions

Past Timber Management and Road Building

All past road construction and timber harvest was summarized by analysis watersheds to reflect the amount of man-caused disturbance in the Robert and Wedge Canyon Fire Areas. This was addressed in the hydrology/watershed affected environment section.

Road Decommissioning, Reconstruction, Rehabilitation, and Relocation

Robert

No road decommissioning, rehabilitation, or relocation has been reported within the Robert Fire cumulative effects area within the past 10 years. Minimal reconstruction has occurred, but exact lengths and locations are not known at this time.

Wedge Canyon

There have been approximately 30.8 miles of road in the Wedge Canyon Cumulative Effects Area decommissioned in the past ten years. An additional 6.75 miles of road were reconstructed. An additional 0.3 miles of road were relocated out of stream bottoms while 18.2 miles were closed to yearlong wheeled vehicles. Another 11.5 miles of roads were removed from the Flathead National Forest Road System. As discussed earlier in the document, there was short-term sediment increases associated with these road management activities. In the long run, sediment yield has been reduced below initial condition.

The Robert and Wedge Canyon Fires

The Robert and Wedge Canyon Fires have been the primary natural disturbance to the cumulative effects project area watersheds since the 1964 flood event. The effects of the Fires were evaluated in the hydrology/watershed affected environment section.

Fire Suppression

The fire suppression activity on the Robert and Wedge Canyon Fires included both ground and aerial attack of the fire, using hand lines, cat (mechanized) lines, fire retardant and water drops from aircraft. The Project File contains a GIS map of the firelines constructed for the Robert and Wedge Canyon Fires. The map reflects both hand lines and cat lines that were constructed. About 26 miles of fireline were constructed for the Robert Fire and 53 miles for the Wedge Canyon Fire. Of this amount, approximately 2 miles were hand line and 24 miles were constructed with mechanized equipment for the Robert Fire. Of the 53 miles of fireline constructed for the Wedge Canyon Fire, approximately 19 miles were hand line and 34 miles were constructed with mechanized equipment. All firelines were rehabilitated as soon as fire conditions made it safe to do so. Rehabilitation included replacing disturbed soil, covering the soil with slash and debris, and the construction of waterbars on slopes. There should be no measurable amount of sediment from the constructed firelines. Inspection of the rehabilitated lines took place in the fall of 2003, and monitoring will continue in the summer of 2004 to insure that the firelines are not channeling sediment to the stream network.

Firelines were constructed within RHCAs in several locations. Some sediment likely entered the creek during the construction of these lines, but the amount would have been very small (estimated to be in the low hundreds of pounds) and impossible to detect versus natural background..

The existing road network was also utilized as fireline in parts of both the Robert and Wedge Canyon Project Areas, requiring the removal of existing vegetation and some soil disturbance, particularly on roads that had been administratively closed for several years. Firelines also crossed both perennial and intermittent stream channels. Approximately 13 crossings were constructed in the Robert Fire Project Area while approximately 65 crossings were constructed during fire suppression activity in the Wedge Canyon Project Area. This work may have resulted in small amounts of additional sediment at these stream crossing sites. Only the portion of the road prism directly 30-40 feet upslope of the fireline crossing would be a potential sediment source, because all firelines were water-barred after the suppression activities. The potential sediment from each stream crossing based upon the WEPP erosion model would be 14.7 pounds per year (.1 ton) until revegetation occurs.

Aerial fire retardant drops with using airplanes was done from July 18, 2003 to August 2, 2003 and again on August 25, 2003 on the Wedge Canyon Fire. Additionally, aerial fire retardant drops were done on the Robert Fire between July 23, 2003 and July 25, 2003 and again between July 27, 2003 and July 30, 2003 and finally on August 2, 2003. There were 41 retardant drops made on the Wedge Canyon Fire and 76 made on the Robert Fire. Approximately 85,362 gallons of retardant were dropped on the Wedge Canyon Fire while 158,232 gallons of retardant were dropped on the Robert Fire. The type of retardant applied in both fire areas was Phos-Chek D75-R retardant. (Information concerning use of fire retardant is in Project File.

The protocols for the use of retardant restrict application within 300' of streams. Norris and Webb (1989) report that when retardant is applied outside the riparian zone there will be minimal long-term effects on water quality. Little and Calfee (2000) reported that there are two possible effects to the water quality that can affect aquatic organisms associated with some types of fire retardant. The first possible effect is the when some types of fire retardant are exposed to sunlight (UV light), the sodium ferrocyanide used as a corrosion inhibitor in the retardant can undergo photoactivation which significantly increases the toxicity of those formulations using sodium ferrocyanide. The Phos-Check D75-R retardant does not contain any sodium ferrocyanide in its formulation. Little and Calfee (2000) reported, "No free cyanide was detected for either Phos-Check D75-R or Phos-Check D75-F under any lighting condition." Therefore, no water quality/aquatic organism effect occurred in the Robert and Wedge Canyon Project Area watersheds from any sodium ferrocyanide associated with the fire retardant.

The second water quality/aquatic organism effect of fire retardant tested by Little and Calfee (2000) is the release of ammonia from the fire retardant into water. The most probable entry of fire retardant into stream water occurs by direct application, or in association with overland water flow. Little and Calfee (2000) reported that for Phos-Check D75-R the un-ionized ammonia ranged from 0.11-0.14 mg/liter, which fell within a range of concentrations that are acutely toxic (0.08-1.1mg/liter) for rainbow trout. Phos-Check D75-R contains 11.3% by weight the active salts ammonia sulfate and ammonia phosphate. Each gallon of mixed retardant contains the equivalent of 1.12 pounds of the Phos-Check D75-R formula. For fires in heavy slash/forest retardant use is at least 6 gallons per 100 square feet (Adams and Simmons, 1999)

To the best of our knowledge (based upon the combination of aerial reconnaissance and walk-through reviews), retardant application did not affect any stream channels in the Robert and Wedge Canyon Project Areas due to either misapplication or wind drift. There were no fish kills noted by either the hydrologist or fish biologist last fall or this spring in any project area rivers or streams. The amount of fire retardant applied in the Robert and Wedge Canyon

Project Area no doubt has increased the post-fire background ammonia levels in project area watersheds more than if none had been applied.

As described earlier in the post-fire nutrient discussion ammonia levels in burned watersheds increase sharply after fires and then return to pre-fire levels rather quickly. This is probably due to the absorption of moderate to low levels of any available ammonia by the volcanic ash topsoil found in this area. Therefore, as Norris and Webb (1989) discussed there should be no long-term effects to the water quality from the application of fire retardant in the upland portions of Robert and Wedge Canyon Project Area watersheds.

Based upon best available information there were no fuel (gasoline or oil) spills associated with the fire suppression activities in any riparian area or stream channel.

Burned Area Emergency Response (BAER) Projects

In the fall of 2003, the BAER team implemented a portion of the Robert and Wedge Canyon Fire BAER Plans. Aerial seeding was completed on both fires in October 2003. Additional completed BAER work involved with the Robert Fire included: a culvert removal and replacement with a new 18” culvert on Forest Road 316, removal of an 18” culvert on Forest Road 10824, installation of an inlet on an existing 18” culvert on Forest Road 1679, installation of an 18” culvert on Forest Road 5271, installation of a 24” culvert and replacement of 2-18” culverts on Forest Road 5225, removal of an 18” culvert, replacement of 24” and 60” inch culverts with the same size culverts, and the installation of a new 36” culvert a culvert on Forest Road 1688. Completed BAER work for the Wedge Canyon Fire included: a culvert replacement on Forest Road 1665 and an armored diversion dip on Forest Road 9805. These projects were implemented because they were considered at high risk of failing as a result of the high peak flows anticipated in the spring of 2004 within the project areas.

Current and Foreseeable Actions

Of the identified reasonably foreseeable actions, there are seven actions that would potentially have any measurable effect to water quantity or quality; they include the following: 1) the proposed culvert removal, replacement, armoring, and cleaning (BMPs), 2) the routine trail maintenance work, 3) the Trail Creek slide stabilization project, 4) the current and future private land development within the project area 5) the routine road maintenance, 6) the road decommissioning as a result of past planning decisions, and 7) the logging in section 16 by the Montana DNRC. These are discussed in the following section. The foreseeable actions on the Flathead National Forest with no effects to the water quality or quantity include: 1) the noxious weed treatments (when accomplished following Flathead N.F. Forest-wide Noxious Weed and Invasive Weed EA direction), 2) recreational activities (e.g. hiking, camping and snowmobile use), 3) special products gathering activities (e.g. mushroom picking, huckleberry picking, appropriate woodcutting), 4) BAER monitoring, 5) shrub and tree seedling planting, 6) temporary road closure orders, 7) fire woodcutting restrictions, 8) and Western Larch Heartrot Study. This interpretation is based upon following the label instructions for proper use of any herbicide, and woodcutters follow the limitations associated with the wood gathering permits.

BMP culvert replacement

For the proposed action, the primary direct effects to the water resource is the potential increase in sedimentation directly associated with either the culvert removal/replacement/armoring/ cleaning process through the BMP project.

The following is an estimate of the total amount of erosion and associated sedimentation that occurs during the process of replacing and/or up-sizing a culvert. The erosion material comes from two different sources. First, the area beneath a culvert in the streambed that is exposed to water-flow during the removal process, and second, the side-slopes of the road prism that are excavated during the replacement process. Unless a stream is dry there is some erosion that occurs in the streambed during the replacement process even with de-watering, due to the seepage of groundwater around or under the stream block. The second source is when the road side-slopes become bare ground following the excavation; even with erosion control and sediment reduction measures installed there is a probability that some erosion would occur before these bare ground surfaces become re-vegetated. Because both of these erosion areas are within or directly next to a stream, any fine eroded soil material may immediately become suspended sediment.

This short-term increase in sediment varies with the soil materials the culvert is in and the slope of the land at the culvert site. In general, the steeper the site the more soil exposed to erosion. Also, in general, the less the coarse fragment content, and the finer the soil texture, the more potential for soil erosion. This is especially true with saturated soils that occur in the bottom of perennial streams. Based upon observations by the Flathead N.F. soil scientist and hydrologist, estimates for the amount of soil erosion from the stream bottom and road side-slopes were developed. These estimated erosion rates were then multiplied by the exposed surface area for various widths and depths of culvert replacements to develop the estimated erosion/sediment potential. Refer to Table 124 for the estimated erosion/sedimentation for various culvert replacement scenarios.

Table 124. Estimated total erosion/sedimentation that occurs during a culvert replacement process, for both shallow and deep sites, during both a normal replacement scenario and a worst-case scenario.

Culvert Width - Erosion Scenario	Estimated Erosion/Sedimentation Flatter/Shallow Site	Estimated Erosion/Sedimentation Steeper/Deep Site
2 Foot – Dry Normal Resize	0.3 Tons/Culvert	1.2 Tons/Culvert
2 Foot – Wet Normal Resize	0.6 Tons/Culvert	1.9 Tons/Culvert
2 Foot – Wet Worst Case Resize	0.8 Tons/Culvert	2.7 Tons/Culvert
3 Foot – Dry Normal Resize	0.4 Tons/Culvert	1.3 Tons/Culvert
3 Foot – Wet Normal Resize	0.7 Tons/Culvert	2.4 Tons/Culvert
3 Foot – Wet Worst Case Resize	1.1 Tons/Culvert	3.5 Tons/Culvert
4 Foot – Dry Normal Resize	0.4 Tons/Culvert	1.4 Tons/Culvert
4 Foot – Wet Normal Resize	0.9 Tons/Culvert	2.9 Tons/Culvert
4 Foot – Wet Worst Case Resize	1.4 Tons/Culvert	4.4 Tons/Culvert

Culvert Width - Erosion Scenario	Estimated Erosion/Sedimentation Flatter/Shallow Site	Estimated Erosion/Sedimentation Steeper/Deep Site
5 Foot – Dry Normal Resize	0.5 Tons/Culvert	1.5 Tons/Culvert
5 Foot – Wet Normal Resize	1.1 Tons/Culvert	3.4 Tons/Culvert
5 Foot – Wet Worst Case Resize	1.7 Tons/Culvert	5.3 Tons/Culvert

Culvert work to be completed through the BMP project was estimated by the district hydrologist and Forest engineer. It is estimated that 7 culverts will be removed along Forest Roads 5225 and 5295 within the Robert Fire Project Area. One-2 foot culvert will be upsized along Forest Road 10844, 2-3' culverts and 2-5' culverts will be upsized along Forest Road 114, 3-4' culverts will be upsized along Forest Road 10355, and 2-4' and 5-3' culverts will be upsized along Forest Roads 9805 and 10881 within the Wedge Canyon Project.

Each of the culverts estimated to need replacement was plotted on a map (Project File). Then, for each potential replacement site the following items were estimated: 1) size of replacement culvert, 2) if the site was a "shallow" or "deep" culvert site, 3) whether the stream at the culvert site was dry, or had stream flow during the potential replacement time-frame, and 4) if due to streambed materials there would be major seepage at the site associated with de-watering. These four estimates were based upon photos of the upper basin sites, and knowledge of the district hydrologist. Based upon these four criteria each potential culvert replacement site was given a potential sediment yield from Table 124 (the estimated erosion/sedimentation associated with a culvert replacement).

Culvert replacement and BMP improvements within the project areas was addressed in a separate Categorical Exclusion (CE), and activities will began in the summer of 2004 and should be completed over the next 2 years or as funding becomes available. Based upon the estimated replacement culvert size and the depth of the road prism the estimated soil erosion/sedimentation from Table 124 was summed for the 22 culvert replacements. The replacement of these 22 culverts would result in the potential release of approximately 15.9 tons of sediment into the streams of the Robert and Wedge Canyon Project Areas.

These estimates are based upon the assumption that each culvert is replaced with a larger capacity culvert. However, in some cases especially on crossing sites with deep fills there is an opportunity to install a second "overflow" culvert, above the pre-existing culvert. This type of installation would yield significantly less sediment because only the road prism side-slopes are a sediment source. This type of installation would only be done on a limited number of sites that have certain landform, channel type, and soil material characteristics.

Other BMP Improvements

Other BMPs that are proposed to be implemented are directly associated with improving water drainage from the surface of roads, and improving the filtering of sediment coming from road surface and ditch drainage. These BMP projects primarily include installation of cross-drains, brushing, maintenance of fill slopes, cut slopes, and ditches, maintenance of roadway surfaces, maintenance of bridges and culverts, upgrading or removing structures to provide for fish passage, and installation of additional road drainage features including rolling dips, drive-thru-dips, and sediment retention structures (silt fencing, straw wattles, slash filter windrows).

There should be no measurable amounts of erosion/sedimentation deliverable to a stream associated with the installation of the above mentioned BMPs. The BMPs will improve road related sedimentation in the long term.

Trail Maintenance

Trail maintenance will occur within the Robert and Wedge Canyon Project Area watersheds. Trail maintenance involves the cutting of trees that have fallen over the trail and installing or improving trail drainage (i.e. water bars). There are very low levels of soil erosion that occur with the maintenance activities associated with the digging-in of replacement water-bars. This activity will produce less than 1 ton of sediment to local rivers and streams.

Trail Creek Slide Stabilization Project

A pre-fire slump, located in the NE1/4 of Section 36 along the northern edge of Trail Creek, was caused by the placement of Forest road 114. The Wedge Canyon fire will increase the erosion from the road cut slopes and fill slopes due to increased overland flow and increased soil dry raveling because of vegetation loss on the cut slope. WEPP Modeling indicates the slide is producing approximately 1.5 tons of sediment to Trail Creek per year with the potential to cause more should the slide fail further. Work is planned through BAER funds to stabilized the the slope to limit further resource damage to the Trail Creek watershed.

Current and Future Private Land Development in the Area

Small private in holdings exist within both the Robert and Wedge Canyon Project Areas. Approximately 355 acres (1%) of the Robert Project Cumulative Effects Area and 1,467 acres (1%) of the Wedge Canyon Project Cumulative Effects Area are privately held. These in holdings are located at the mouths of Trail, Tepee, and Whale Creeks within the Wedge Canyon Project Area and within the North Fork Face drainages in the Robert Fire Project Area. Short term minor disturbance will occur with future development of these lands for second home dwellings. The initial impacts are likely to be minor and negligible into the future. These developments will have localized minor impacts but will not cumulatively impact the watersheds negatively

Routine Road Maintenance

Routine road maintenance (primarily road blading and culvert cleaning) will be accomplished within the Robert and Wedge Canyon Project Areas. Road blading typically occurs annually, and the culvert cleaning is done on an as needed basis. Road maintenance did occur within the project areas during and after fire suppression activity in the summer of 2003. Forest budget constraints will limit the amount of maintenance completed over the next 5 years. Forest roads are prioritized based on their impacts to resources and importance to the Flathead National Forest Travel Management Plan. Roads within the Project Areas will be maintained when funding is available and the road priority is high enough.

Road Decommissioning as a part of past planning decisions

Both the Robert and Wedge Canyon Project Areas have past road management decisions which have not been implemented. The Center Mountain Roads Reclamation Decision and Hornet Wedge Decision Notice will decommission 7 miles of road within the Lower Whale Grizzly Bear Subunit and 3 miles within the Upper Whale Shorty Grizzly Bear Subunit. The Moose Post-Fire Record of Decision will decommission 45 miles within the Lower Big

Grizzly Bear Subunit. Decommissioning of these roads will benefit water quality, reducing sediment yields to project area watersheds while improving fish and aquatic habitat.

Logging by the Montana DNRC

The Montana Department of Natural Resources and Conservation (DNRC) is currently logging Section 16 in both the Tepee and Whale Creek drainages. Approximately 197 acres were tractor logged during the winter of 2003-2004. An additional 30 acres will be skyline logged by the end of this summer (2004). As discussed in the Hydrology Affected Environment Section, winter tractor and skyline logging have low impact to the soil resource. The State of Montana follows BMPs much like those proposed for the Robert Wedge Salvage Sale Project. Should the project design measures, BMPs, and mitigation measures be followed, impacts will be isolated and soil and water resources will be protected into the future.

Alternative 1 (No Action)

Past Actions: The past actions described earlier in this section include: past road construction, past timber harvest, past road decommissioning, the Robert and Wedge Canyon Fires, the fire suppression activities for the Robert and Wedge Canyon Fires, and the Burned Area Emergency Rehabilitation for the Fires.

Foreseeable Actions: The foreseeable actions that may affect the water resources were described earlier in this section and include: 1) the proposed culvert work, 2) the proposed Best Management Practices (BMP's) road drainage improvements, 3) the Trail Creek Slide Stabilization Project 3) the trail maintenance work, 4) private land development, 5) routine road maintenance, 6) road decommissioning as a result of past planning decisions, and logging by the MDNRC. Refer to Table 125 for a listing of the Robert and Wedge Canyon Project Area watersheds existing post-fire sediment yield, and other foreseeable actions listed under the No Action Alternative.

Table 125. The Summary of the Sediment Producing Activities in the Robert and Wedge Canyon Project Areas Including Background, and Foreseeable Actions.

Sediment Producing Activity	Tons of Sediment
Annual Sediment Yield for Non-burned Portion of Robert and Wedge Canyon Project Area watersheds	Robert : Less than 1 ton/ Wedge Canyon: Less than 1 ton
Year-2 Post-fire Potential Sediment from Burned Portion of Robert and Wedge Canyon Project Area watersheds	Robert: 22,567/ Wedge Canyon: 7,774
Fire Suppression (Catlines)	Robert: 1.3/ Wedge Canyon: 13.4
BAER culvert replacements	Robert: 2.2/ Wedge Canyon: 0
Annual Road Maintenance Potential Sediment in Robert and Wedge Canyon project area watersheds	Robert: Less than 1 ton/ Wedge Canyon: Less than 1 ton
Total Short-term Potential Sediment Increase from Hornet, Center Mountain Roads, and the Moose EIS Road Decommissioning Projects	Robert: 18 tons/ Wedge Canyon: 4 tons

Sediment Producing Activity	Tons of Sediment
Annual Potential Sediment from Installation of Road BMP's Structures	Robert: 0.1/ Wedge Canyon: 0.1
Total Short-term Potential Sediment from Culvert Replacements	Robert: 47.2/ Wedge Canyon: 22

Proposed Actions: There are no proposed actions on federal lands under the No Action Alternative. Given a conservative precipitation/runoff event, and based upon the observations of the current and former Flathead National Forest soil scientists of other major wildfires in the area, the estimated year-2 post-fire potential sediment yield to streams would be approximately 4,415 tons/year for the Robert Fire Project Area and 3,088 tons/year for the Wedge Canyon Project Area. Combining that estimate with the non-burned fire background, and assuming all of the foreseeable actions were implemented in the summer of 2004; the sediment yield to streams for the 2005 snowmelt period would equal approximately 70 additional tons to Robert Fire Project Area watersheds and 40 additional tons to Wedge Canyon Project Area watersheds. This equates to an increase of approximately 1.5% above natural sediment delivery rates for Robert Project Area streams and 1.3% above natural sediment delivery rates for the Wedge Canyon Project Area streams. These increases are considered minor and are within the error of the WEPP Model (plus or minus 50 percent). Neither increase will impact water quality in regards to fish and aquatic habitat above what the fire will affect.

Additionally, these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for the project area watersheds. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation for project area watersheds. Given a significant storm/soil erosion event, the sediment yield for project area streams could exceed the measured natural range of variation. This interpretation is based upon past monitoring reports, literature, and professional judgment.

A cumulative effect decrease to the long-term sediment and water yield would be foregone if the road decommissioning proposed in the Action Alternative were not implemented.

Alternative 2 (Proposed Action)

Past Actions: The past actions are the same as described for Alternative 1 (No Action).

Foreseeable Actions: The foreseeable actions are the same as described for Alternative 1 (No Action).

Proposed Actions: Alternative 2 (Proposed Action) proposed salvage harvesting, road/landing construction, and road decommissioning would not cause any measurable increases in water yield. Rather, the level of post-fire water yield increase diminishes by the time the salvage harvest and road decommissioning would be implemented.

The proposed salvage harvest and road/landing construction under the Action Alternative would increase the sediment loading to streams in twelve analysis watersheds, for a total of approximately 373 tons in the entire Robert Project Area and 159 tons in the Wedge Canyon Project Area. In addition, 70 tons in the Robert and 40 tons in the Wedge Canyon Project Areas will be delivered to project area streams from proposed activities. The road decommissioning would have a positive long-term effect of decreasing water yield and reducing sedimentation (reduction of 3 tons/years for the Robert and 2 tons/year for Wedge Canyon), after the initial short-term sediment increase (47 tons for Robert and 22 tons for

Wedge) during the culvert removal/stream readjustment time. The risk of culvert failure would also decrease with the proposed road decommissioning. The effect of the sediment yield increase from the Action Alternative proposed actions would not cause any of the individual analysis watersheds to become functioning-at-risk. Refer to Table 126 for a listing of the Robert and Wedge Canyon watersheds existing post-fire sediment yield, the additional sediment yield from the Action Alternative proposed actions and other foreseeable actions.

Table 126. The Summary of the Sediment Producing Activities in the Robert and Wedge Canyon Project Areas Including: Background, Foreseeable Actions, and Alternative 2 Proposed Actions.

Sediment Producing Activity	Tons of Sediment
Annual Sediment Yield for Non-burned Portion of Robert and Wedge Canyon Project Area watersheds	Robert : Less than 1 ton/ Wedge Canyon: Less than 1 ton
Year-2 Post-fire Potential Sediment from Burned Portion of Robert and Wedge Canyon Project Area watersheds	Robert:: 22,567/ Wedge Canyon: 7,774
Fire Suppression (Catlines)	Robert: 1.3/ Wedge Canyon: 13.4
BAER culvert replacements	Robert: 2.2/ Wedge Canyon: 0
Annual Road Maintenance Potential Sediment in Robert and Wedge Canyon project area watersheds	Robert: less than 1 ton/ Wedge Canyon: Less than 1 ton
Total Short-term Potential Sediment Increase from Hornet, Center Mountain Roads, and the Moose EIS Road Decommissioning Projects	Robert: 18 tons/ Wedge Canyon: 4 tons
Annual Potential Sediment from Installation of Road & Trail BMP's Structures	Robert: 0.1/ Wedge Canyon: 0.1
Total Short-term Potential Sediment from Culvert Replacements (Road Decommissioning	Robert: 47.2/ Wedge Canyon: 22
First Year Potential Sediment from the Action Alternative Proposed Salvage1	Robert: 373/ Wedge Canyon: 159
Total Short-term Potential Sediment Increase from the Action Alternative Road Decommissioning	Robert: 3/ Wedge Canyon: 2
Annual Long-term Potential Decrease Sediment from the Action Alternative Road Decommissioning2	Robert : Less than 1 ton/ Wedge Canyon: Less than 1 ton

1 Note that the sediment yield from salvage harvesting decreases rapidly as revegetation occurs.

2The decrease in sediment from the road decommissioning reflects the annual yield of sediment from the existing road system proposed for decommissioning.

Given a conservative precipitation/runoff event, and based upon the observations of the current and former Flathead National Forest soil scientists of other major wildfires in the area, the estimated year-2 post-fire potential sediment yield would be approximately 4,861 tons/year for Robert Fire Project Area watersheds and 3,276 tons/acre for Wedge Canyon Project Area watersheds. This is 446 tons more than existing condition and 376 tons more than the no action alternative with foreseeable actions implemented for the Robert Fire Project Area and 188 tons more than the existing condition and 148 tons more than the no action alternative with foreseeable actions implemented for the Wedge Canyon Fire Project Area.. This equates to an increase of approximately 10% above natural sediment delivery rates for Robert Project Area streams and 6% above natural sediment delivery rates for the Wedge Canyon Project Area streams. Like the no action alternative, these increases are considered minor and within the error of the WEPP Model (plus or minus 50 percent). Essentially, neither increase will impact water quality in regards to fish and aquatic habitat above what the fire will affect.

Due to the effect of increased sedimentation and slightly decreased ground cover associated with the salvage logging proposed in the action alternative, there should be a slight increase in the level of nutrients i.e. nitrogen and phosphorus. This nutrient increase should be very small in comparison to the nutrient increase caused by the wildfire. In combination the amount of potential nutrient increase from the action alternative timber salvage and road/landing construction would not be discernable from the nutrient increase due to the wildfire. And the overall increase in nutrient levels should not be measurable above natural variation once project area watersheds combine with the North Fork of The Flathead River

Cumulatively these actions should not have a measurable increase to water yield, and/or nutrient levels that is outside the measured natural range of variation for Robert and Wedge Canyon watersheds. Given normal climatic events in the next two years the sediment yield would also be in the natural range of variation for project area streams. Given a significant storm/soil erosion event, the sediment yield for project area streams could exceed the measured natural range of variation. These interpretations are based upon past monitoring reports, literature, and professional judgment.

3.5.4 Regulatory Framework and Consistency

Clean Water Act

All alternatives would comply with the Federal Clean Water Act. Section 313 of the Clean Water Act requires that Federal agencies comply with all substantive and procedural requirements related to water quality. Under Section 303 of the Clean Water Act, states have the primary responsibility to develop and implement water quality programs, which include developing water quality standards and Best Management Practices (BMPs). State water quality standards are based on the water quality necessary to protect beneficial uses.

Environmental Protection Agency policy requires each state to implement a Non-degradation Policy. Under this policy, water quality must be maintained to fully support existing beneficial uses. Existing water quality that is higher than the established standards must be maintained at the existing level unless the board of health and environmental sciences determines that a change in water quality is justifiable due to social and/or economic reasons (CFR Vol. 48, No. 217, 131.12, Nov, 8, 1983; Montana Water Quality Act, Section 75-5.)

Montana State Water Quality Law

All alternatives would comply with Montana State water quality laws. As listed in ARM 17.30.608 (1) the State of Montana has classified the waters in all project area watersheds as B-1. Waters classified as B-1 are suitable for drinking, culinary, and food processing purposes after conventional treatment. Water quality must also be suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply. Additional criteria specific to sediment are found within Section 17.30.623(2)(f) of Montana Water Quality Standards where it is stated that "(N)o increases are allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids, which would or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife". Naturally occurring is as defined by MCA 17.30.602 (17), includes conditions or materials present during runoff from developed land where all reasonable land, soil, and water conservation practices (BMPs) have been applied. Reasonable practices include methods, measures or practices that protect present and reasonably anticipated beneficial uses.

The state water quality law relates to the Clean Water Act and the maintenance of beneficial water uses through the use of BMPs. The BMPs are designed to prevent soil erosion and protect water quality, as well as help prevent soil damage. In a memorandum of Understanding with the State of Montana, the Forest Service has agreed to follow Best Management Practices (BMPs) during timber harvest and road construction activities. The Robert Wedge Post-Fire Project would utilize all applicable BMPs during project design and implementation as described in Best Management Practices for Forestry in Montana – 1997. Also Forest Service - Soil and Water Conservation Practices (FSH 2509.22) would be combined with Montana State BMPs for incorporation into project design and implementation to ensure that soil and water resources are protected. The project specific BMPs are identified in the Appendix C of the Draft EIS.

The DEQ's 1996 and 2000 303 (d) Reports - Water bodies in need of Total Maximum Daily Load (TMDL) Development, describe Whale Creek as partially supporting the beneficial uses of aquatic life support and cold water fishery. The probable causes of this impairment on both the 1996 and 2000 303(d) lists can all be linked to sediment, with probable sources being linked primarily to silviculture practices. Development of a TMDL for Whale Creek is ongoing.

Montana Streamside Management Zone (SMZ) Law

Both alternatives would comply with the Montana SMZ Law. By definition in ARM 36.11.312 (3), the majority of the streams in Big Creek meet the criteria for a class 1 stream. There are some first order ephemeral streams that meet the criteria of a class 2 or 3 stream based upon site-specific criteria. All alternatives would meet at a minimum SMZ buffer zone requirement. In most situations because of the INFISH, the RHCA width requirements and/or the expanded RHCA buffer width, the required SMZ buffer width is expanded significantly.

Consistency with Forest Plan Standards

All alternatives would comply with The Flathead National Forest Plan direction regarding aquatic resources. The Flathead Forest Plan directs under Forest-wide Management Direction that: 1) Develop watershed activity schedules for key watersheds. 2) Maintain an inventory of non-wilderness areas needing soil and water restoration. Complete restoration projects as funds permit. 3) Best Management Practices would be applied during Forest Plan implementation to ensure that Forest water quality goals are met. And under Management Area specific water and soils direction to: 1) Maintain long-term water quality to meet or exceed State water quality standards. To ensure meeting these standards, surface-disturbing activities would be monitored where this need is identified. 2) Refer to Forest-wide standards under Water and Soils for Best Management Practices, Landtype Guidelines, and standards applicable to projects or activities within this Management Area. 3) All Project proposals would be analyzed and evaluated to determine the potential water quantity and quality impacts. Mitigation measures would be developed to minimize adverse impacts. These water and soils standards were reviewed for all proposed management activities on management areas MA 9, MA 13, MA 13a, MA 15, and MA 18. All proposed management actions in all the alternatives meet these forest plan standards.

INFISH Standards

The INFISH (1995) Standards are discussed in detail in the fishery assessment. All units were designed to meet the RHCA requirements under the Flathead Forest Plan as amended by INFISH to protect the stream channel and maintain water quality and the aquatic habitat.

Wetlands

Wetlands are protected under Executive Order 11990. This act directs federal agencies to "minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands...". There are no activities proposed in any of the alternatives of the Robert-Wedge Post-fire Project that directly affect any lotic or lentic wetlands in Robert or Wedge Canyon Project Area streams or along the North Fork of the Flathead River in the project area. Therefore all alternatives would meet Executive Order 11990.

Regulatory Consistency

All of the proposed alternatives would meet Clean Water Act, Montana State Water Quality Standards, and Forest Plan Water Standards.

3.6 SOILS

3.6.1 ANALYSIS AREA AND INFORMATION SOURCES

The 29,346-acre soil analysis area for the Robert Fire encompasses all lands within the watershed boundaries of Canyon, Deep, and Hell Roaring creeks and the unnamed face drainages affected by the fire that drain directly to the North Fork Flathead River. The 94,389-acre soil analysis area for the Wedge Canyon Fire encompasses all land within the Trail, Yakinikak, Tepee, and Whale Creek drainages as well as the unnamed tributaries affected by the fire that drain to the North Fork Flathead River. The analysis areas were selected because all of the proposed management activities will occur within these watersheds. Approximately 148 acres (less than one percent) of the burn occurred within the Big Creek watershed, and 12 acres occurred in the Spoon Lake drainage. These areas will not be included in this analysis and will not have salvage activity in them.

Information sources for the soils analysis include a landtype map for the project area, the updated landtype report for the Flathead NF (Martinson and Basko 1998), a map of burn severity ratings (Figure 10 and Figure 14) and unit location, the Soils Report for the Burned

Area Emergency Response (BAER) project, the Forest's timber stand and roads databases, and the Region 1 Soil Analysis Guideline.

3.6.2 AFFECTED ENVIRONMENT

This section discusses the existing condition and affected components of the soil resource and how past management activities and the Robert and Wedge Canyon fires have affected the soil resource. Components to be discussed in detail are soil productivity, soil erosion, and mass failures.

Disturbances

Natural and human-related disturbances have affected the soils in the analysis area. Natural disturbances of the soil include glacial activity, floods, mass erosion, drought, insects, plant disease, and wildland fires. Natural disturbances can alter long-term soil conditions. The Robert and Wedge Canyon Fires were the most recent natural disturbance in their respective analysis areas.

Human disturbances have occurred in the analysis area for possibly hundreds of years. The extent and degree of human disturbance, however, has been most pronounced in recent times. Recent disturbances include such activities as road construction, timber harvest, prescribed fire, fire suppression, and recreational activities. Human disturbances can affect long-term soil productivity by committing areas to specific uses (e.g. roads, campgrounds), or disturbing the soil by compaction, rutting, puddling or displacement, or by accelerating erosion.

The Effects of Fire on Current Soil Condition

The primary means of discussing the post fire conditions of soils is burn severity, which was mapped following the Robert and Wedge Canyon Fires (refer to Figure 37 and Figure 38, Table 127 and Table 128). Burn severity describes the fire-caused damage to the soil. Burn severity is a measure of the effects of fire on soil conditions including how water moves into and through the soil (hydrologic properties). Together with slope, burn severity influences the amount of soil erosion following a fire.

Burn severity classes are identified as low, low/unburned, moderate, moderate/unburned or high, as described in Table 129.

Table 127. Soil Burn severity acreage for the Robert Fire[1].

Burn Severity	Acres[1]	Percent
High	4,973	11
Moderate	16,821	37
Moderate/Unburned Mosaic	993	2
Low (20-80%)/ Unburned Mosaic	10,411	23
Low (0-30%)/ Unburned Mosaic	11,873	27
Total	45,071	100

Table 128. Soil Burn severity acreage for the Wedge Canyon Fire[1].

Burn Severity	Acres	Percent
High	3,588	9
Moderate	30,084	71
Moderate/Rock Outcrop	683	2
Low (20-80%)/ Unburned Mosaic	5,552	13
Low (0-30%)/ Unburned Mosaic	2,132	5
Total	42,039	100

[1] **Acreages in the above tables reflect the August 20, 2003 burn severity map for the Wedge Canyon Fire and the August 28, 2003 burn severity map for the Robert Fire. Both fires include acres of land burned in Glacier National Park.**

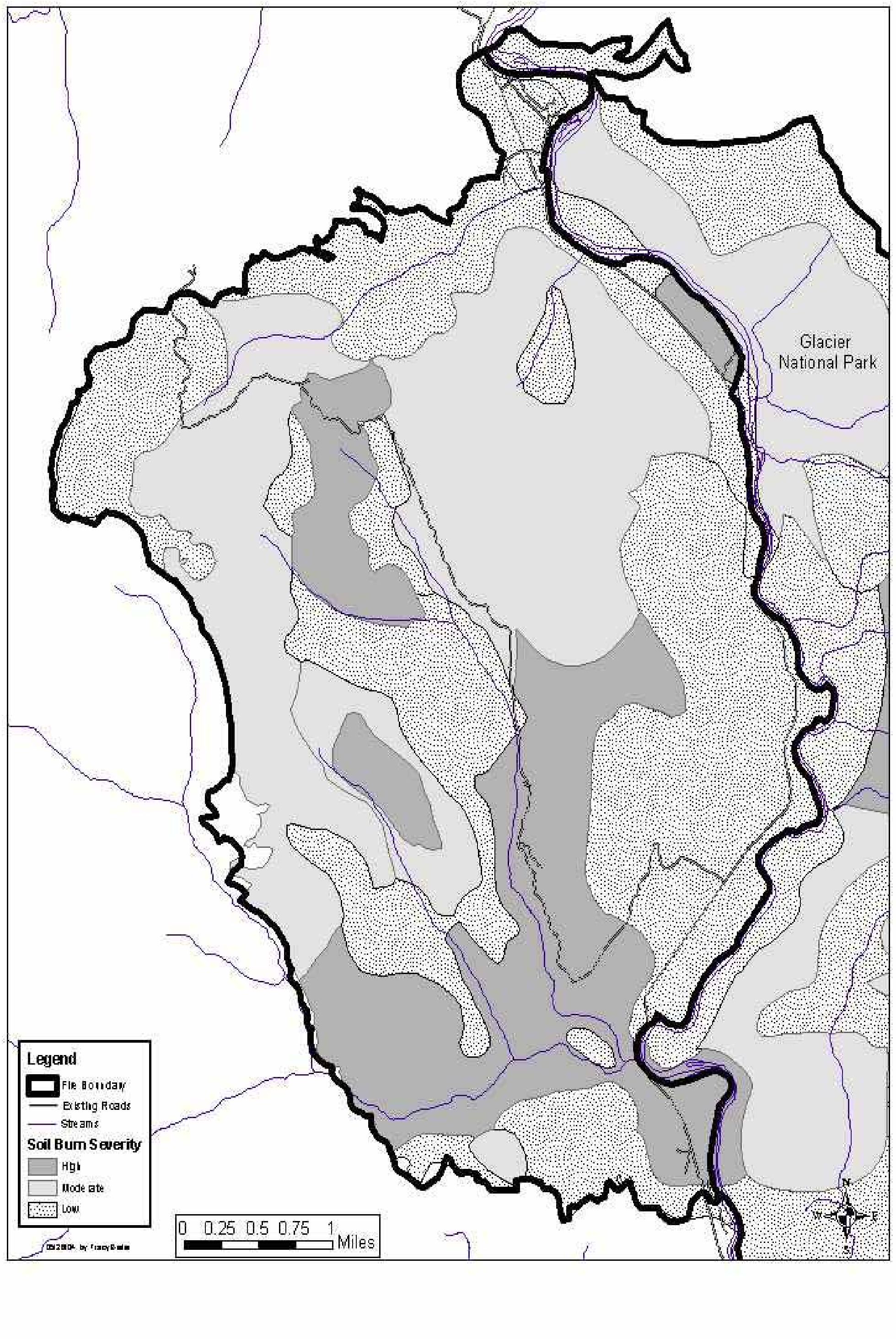

Figure 37. Burn Severity Effects on Soil – Robert Fire Area

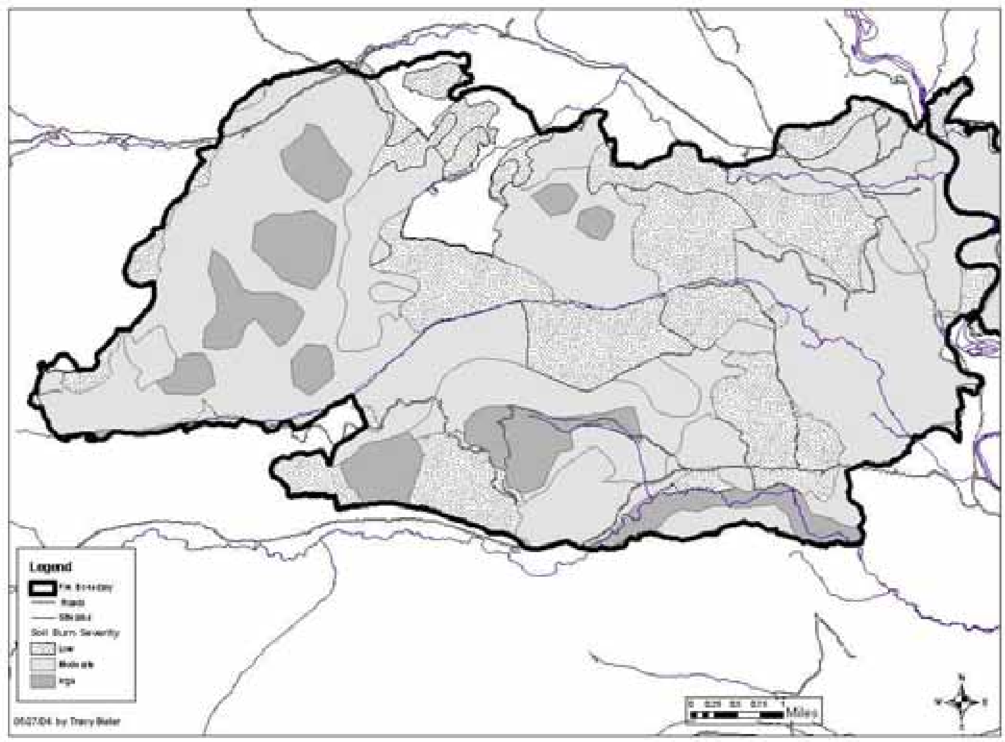

Figure 38. Burn Severity Effects on Soil – Wedge Canyon Fire Area

Table 129. Description of Burn Severity Classes

Low	Duff layer partially consumed by the fire; very little heating of the soil surface layer. Fire does not affect the soil hydrologic properties. Many unburned roots and seeds in the surface soil will aid in vegetating burned areas. Natural re-vegetation on these sites will occur quickly. Typically, unburned trees and shrubs are present and provide cover that reduces soil erosion. Management using ground-based equipment is unlikely to increase soil erosion over that of similar unburned sites.
Moderate	Slightly altered surface soil structure, reduced numbers of fine roots and less seed viability in the soil surface. Natural re-vegetation on these sites is slower than a low burn severity site. In most places the duff is reduced to a layer of charred litter. Hydrophobic soil conditions may occur under moderate burn severity sites, but are usually spotty and short-lived. More likely to lead to increased soil erosion if disturbed by ground based logging equipment or other disturbances. However, erosion control practices are effective on these sites and must be applied. Also susceptible to physical disturbance caused by equipment.
High	Modified surface soil properties. Surface soil structure has broken

	down, and hydrophobic layer may be present. Soil conditions and a lack of organic litter or duff allows for rain-impact erosion at the soil-air interface, reduced infiltration, and increase erosion and runoff. Few viable roots or seeds in the upper several inches of the soil. Natural revegetation on these sites is slow. Soils highly susceptible to erosion and physical soil disturbance, especially when ground based equipment operates. Require special mitigation measures and management practices to reduce soil erosion. Highest potential for erosion is on these soils located on steep slopes.

Water Repellent (Hydrophobic) Soils

Soil can become water repellent following a fire. The Robert and Wedge Canyon Fire BAER Team tested for water repellant (hydrophobic) soils within both fire boundaries. During those BAER field examinations, it was discovered that many of the high and moderate burn severity sites on non-volcanic ash soils recorded water repellency. Hydrophobic soil conditions were discussed in detail in the BAER report for the fires (USDA Forest Service, Flathead National Forest 2003). A study of hydrophobic soils on the Tally Lake Ranger District of the Flathead NF indicates that hydrophobic soil conditions are temporary on fine textured soils and will naturally decline as fall rains and melting snow wet the soil profile (DeByle 1973, page 86). On May 24, 2004 (less than a year after the fire), a field investigation by Flathead National Forest Soil Scientist Bill Basko of both the Robert and Wedge Canyon Fire showed that soils were wet throughout their depth, indicating they were no longer hydrophobic.

Fire and Soil Productivity

Fire alters soil properties including organic matter content and nutrient related processes. Many studies have shown leaching of soil nutrients, mainly nitrogen, following fires. Studies within the Flathead Basin have shown this occurs here. However, the local studies indicate that this was a short-term loss, usually diminishing within weeks of the fire (Spencer and Hauer 1990).

Fire alters nutrient cycling and soil productivity in several ways. Soil erosion caused by wildfire reduces soil productivity if it is severe and widespread. Nutrients, mainly nitrogen, are volatized during fires and leave the site with the smoke. At the same time, the ash that falls to the ground is rich in nutrients, including nitrogen, and taken up by the first plants that germinate or sprout. Severe fires that kill all the seeds and roots in the soil slow the establishment of vegetation. This condition increases the risk that nutrients, especially nitrogen, will leach beyond the presence of roots and find its way into ground water and streams (Debano et. al. 1998, p 108-114).

Fire plays a natural role in balancing vegetation systems with site, soil and climate (Harvey and others, 1994, page 43). Fire recycles stored carbon and nutrients back to the soil to be used again by the next generation of plants. Fire has been a part of the Robert and Wedge Canyon project area ecosystems since the glaciers retreated some 10,000 years ago. Numerous wildfires have run their course in the watersheds affected by the Robert and Wedge Canyon Fires in the past. After each fire, vegetation has returned, demonstrating the resiliency of the soils.

Fire and Soil Erosion

As noted by Beschta et al.(1995), soils are vulnerable in a burned landscape. Areas of soil erosion within the burned areas will persist until the sites re-vegetate or there are sufficient accumulations of organic materials on the soil surface. Areas of overland flow will occur where the amount of precipitation and/or snowmelt water exceeds the infiltration rate of the soil. If insufficient cover is present on these sites soil erosion will occur. However, there have been numerous fire cycles in this area since the glaciers melted 10,000 years ago. At times, large areas lacked vegetation and the soils were exposed to the erosive forces of rains, wind, and snowmelt. The current landscapes in both the Robert and Wedge Canyon project areas shows little evidence that extensive erosion has occurred since the deposition of the volcanic ash layer 6,600 years ago from the eruption of Mt. Mazama in southwest Oregon. The Robert and Wedge Canyon BAER Teams designed several erosion control measures to reduce soil erosion potential. Approximately 678 acres were seeded along Canyon Creek in the Robert Fire area and approximately 442 acres were seeded in the Wedge Canyon Fire Area in Trail, Whale and Tepee Creeks. These treatments were intended for the most erosion prone areas on high soil burn severity sites.

Fire and Mass Failures

Fire can affect slope stability. The potential for mass movement can increase when there is high vegetation mortality, particularly trees and shrubs, on slopes already prone to landslides. Loss of vegetation increases the amount of water in the soil. The soil strength that tree and shrub roots provide decreases when vegetation dies and roots decompose.

No natural slumps occur in the Robert or Wedge Canyon fire areas. A pre-fire slump, located in the NE1/4 of Section 36 along the northern edge of Trail Creek, was caused by the placement of Forest road 114. The Wedge Canyon fire will increase the erosion from the road cut slopes and fill slopes due to increased overland flow and increased soil dry raveling because of vegetation loss on the cut slope.

The Flathead NF hydrologist noted two new slumps during an April 2004 helicopter flight over the fires. Both slumps are located within the Robert fire area and both occurred during the winter of 2003-2004. The first, located within the Canyon Creek intergorge area just downstream from the confluence with McGinnis Creek, is approximately 60 feet long, 15 feet wide and 3 feet deep. The second slump, located just south of Forest road 803 approximately 0.5 miles west of its intersection with the main North Fork Flathead River road, is approximately 80 feet long, 15-20 feet across, and 1.5 feet deep. The first slump was solely fire induced while the second slump was caused by a combination of post fire conditions and road placement. Both slumps added small sediment amounts to the Canyon Creek system. The amount of these mass failures occurring in the Trail and Canyon Creek areas is minimal as compared to other landscapes that are more sensitive to post-fire mass failure. This amount of small road-associated mass failure is not unusual during a wet spring following a fire within the project area.

Human Disturbances and Existing Soil Condition

Timber Harvest, Roads and Fire Suppression in the Analysis Area

Timber harvest, roads and fire suppression have altered soils in the analysis area. The Forest's timber stand and roads data bases, along with literature and personnel observations of the effects of management on soils, were used to estimate soil effects and the amount of soil with reduced soil productivity. These estimates are shown in Table 130.

Table 130. Existing Soil Disturbance in the Robert and Wedge Canyon Soils Analysis Areas

Fire (acres)	Skid Trails & Landings from Past Harvest (acres)	Roads (acres)	Disturbed by Robert Fire Suppression (including Hazard Tree Removal) (acres)	Trail System (acres)	Detrimental Disturbance (acres and percent of analysis area)
Robert (29,346)	3,559	118	73	2	3,752 (13%)
Wedge Canyon (94,389)	5,859	189	100	16	6,164 (7%)

Activity Areas

The effects analysis follows the process described in the Soil Analysis Guideline contained in the project files. Cumulative effects are discussed in terms of both the analysis area, described above and the project activity areas. Activity areas are the proposed salvage harvest units. They are a subset of the larger analysis area. The soils analysis is based on the amount of detrimental soil condition before and after the proposed management activities. Detrimental soil conditions are defined as the condition where established soil quality standards are not met and the result is a significant change in soil quality (Forest Service Manual, R-1 Supplement No. 2500-99-1, 1999).

It is also necessary to look at the existing condition of the proposed activity areas within the project. The Region 1 Supplement 2500-99-1 defines an activity area as a land area affected by a management activity to which soil quality standards are applied. An example is a harvest unit within a timber sale. It also states that in areas where less than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects of the current activity following project implementation and any needed restoration activities must not exceed 15 percent. In areas where more than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects from project implementation and needed restoration activities should not exceed the conditions prior to the planned activity and should move toward a net improvement in soils quality.

In conjunction with the timber stand database and aerial photographs, proposed salvage units within both the Robert and Wedge Canyon Fire Areas with previous management activity will be individually examined on the ground in the late spring and early summer of 2004 to quantify the existing amount of detrimental soil disturbance (refer to Table 130). Until this monitoring is completed, it will not be known which units are meeting this Region 1 Supplement. Results of data collected will be included in the Final EIS for this project. Proposed salvage units could be dropped from harvest consideration or additional project design features or mitigation measures would be applied, should existing condition show that the 15% threshold is exceeded. Table 131 and Table 132 show which units will be examined in the spring and summer of 2004, the acres in each unit, the previous timber harvest activity in the unit, and the date(s) of the previous harvest activity. Existing percent detrimental soil disturbance will be disclosed in the Final Robert-Wedge EIS.

Table 131. Proposed Cutting Units with Previous Timber Harvest within the Robert Project Area

Unit Number	Acres in Proposed Units	Previous Activity/Acres of Previous Activity	Date of Previous Activity
303	16	Salvage/ 12	1980

Unit Number	Acres in Proposed Units	Previous Activity/Acres of Previous Activity	Date of Previous Activity
309	9	Salvage/ 1	1976
312	341	Salvage/ 69	1966, 1976, 1992
313	1,319	Salvage/ 17	1976
317	197	Salvage/ 136	1976
324	28	Salvage/ 28	1980
325	23	Salvage/ 4	1980
327	34	Salvage/ 12	1992
328	24	Overstory removal/ improvement/ 24	1950
329	45	Overstory removal/ improvement/ 42	1965, 1966
330	75	Overstory removal/ improvement/ 8 Salvage/ 48	1965, 1974, 1978, 1985
331	38	Salvage/ 38	1976
332	107	Salvage/ 73	1975, 1976, 1987, 1992
333	25	Salvage/ 25	1976
334	31	Overstory removal/ improvement/ 14 Salvage/ 17	1965, 1966, 1992
340	8	Salvage/ 8	1979
341	72	Overstory removal/ improvement/ 65 Salvage/ 1	1966, 1967, 1977
343	15	Miscellaneous partial cut/ 15	1987
344	24	Salvage/ 19	1976
345	127	Overstory removal/ improvement/ 14 Salvage/ 30	1959, 1976
346	2	Salvage/ 2	1976
347	10	Salvage/ 10	1976
351	19	Salvage/ 2	1992
353	19	Regeneration/ 3	1961
355	2	Salvage/ 2	1976
356	1	Salvage/ 1	1976
357	5	Salvage/ 5	1976
358	1	Salvage/ 1	1976
359	7	Salvage/ 7	1976
360	27	Salvage/ 27	1976
361	7	Salvage/ 7	1976
362	6	Salvage/ 6	1992

Unit Number	Acres in Proposed Units	Previous Activity/Acres of Previous Activity	Date of Previous Activity
363	7	Salvage/ 7	1992
364	19	Overstory removal/ improvement/ 19	1966
365	1	Overstory removal/ improvement/ 1	1966
367	50	Overstory removal/ improvement/ 50	1950
368	9	Salvage/ 9	1976
370	36	Overstory removal/ improvement/ 25	1959
371	50	Salvage/ 43	1975, 1976, 1987
374	51	Salvage/ 43	1976
375	12	Salvage/ 12	1976
376	7	Salvage/ 7	1976
377	136	Salvage/ 20	1992
378	38	Overstory removal/ improvement/ 16 Salvage/ 17	1966, 1977, 1992, 1993
381	13	Regeneration/ 2 Salvage/ 11	1964, 1967, 1979
382	9	Salvage/ 9	1979
383	3	Salvage/ 3	1979
384	16	Regeneration/ 3 Salvage/ 12	1964, 1979
385	7	Overstory removal/ improvement/ 6	1964
386	11	Salvage/5	1979

Table 132. Proposed Cutting Units with Previous Timber Harvest within the Wedge Canyon Project Area

Unit Number	Acres in Proposed Units	Previous Activity/Acres of Previous Activity	Date of Previous Activity
117	16	Overstory improvement/removal/ 2 Salvage/ 14	1969, 1979
118	29	Salvage/ 29	1979
119	8	Salvage/ 8	1979
120	34	Salvage/ 34	1979
121	56	Overstory improvement/removal/ 56	1975, 1976, 1977

125	65	Salvage/ 12	1979
128	226	Salvage/ 81	1960, 1979, 1986
129	25	Salvage/ 20	1979
132	183	Salvage/ 183	1960, 1976
133	64	Overstory improvement/removal/ 1 Salvage/ 41	1960, 1963
136	20	Overstory improvement/removal/ 20	1962
137	16	Overstory improvement/removal/ 16	1967
138	22	Overstory improvement/removal/ 11	1962
139	28	Overstory improvement/removal/ 28	1975
141	50	Overstory improvement/removal/ 8	1962
144	95	Overstory improvement/removal/ 77	1962, 1969, 1975
146	30	Salvage/ 12	1975
147	30	Salvage/ 26	1979
149	106	Salvage/ 20	1979, 1980
151	18	Salvage/ 11	1979
152	17	Salvage/ 3	1978, 1979
157	18	Salvage/ 18	1991
160	5	Salvage/ 5	1979
161	7	Salvage/ 7	1979
162	45	Salvage/ 17	1979

Soil Productivity

Soil productivity is the ability of the soil to supply the water and nutrients needed to sustain plant growth. Productivity reflects soil properties such as depth, texture, and parent material. Productivity is affected by changes in organic matter, in the populations of soil microorganisms, and in physical soil properties. These changes can be caused by management activities. Changes in soil productivity brought about by the implementation of an action alternative would be temporary. Natural processes such as freeze-thaw and root growth eventually loosen compacted soils. A literature review and assessment by Gonsior (1983, pages 13-15) mentions a maximum time for recovery of 70 years. Rutting and puddling are soil disturbances that are similar to compaction and would be expected to last a similar time. Displacement, the loss of topsoil, is a long term, and perhaps permanent loss of soil productivity. However, the management practices outlined in Chapter 2.

Organic Matter - Organic matter in its various forms influences soil productivity. Humus is organic matter that has been decomposed by microorganisms and whose source is not recognizable. Duff and litter are leaves, needles, and twigs that are still recognizable on the surface of soils. Large woody debris consists of woody stems greater than 3 inches in diameter (Harvey et al. 1994, page 10). Large woody debris supplies moisture to plants after the soils dry out. All organic matter provides habitat and nutrients for soil organisms.

Soil Organisms - Soil organisms, including fungi and bacteria, decompose organic matter, which releases nutrients for plant growth. Soil organisms depend on organic matter for the nutrients they need to carry out their life processes. For example, large woody debris provides important habitat for the survival of mycorrhizae fungi. These fungi form a symbiotic relationship with tree roots, increasing water and nutrient uptake by the trees and the fungi (Perry et al. 1990, page 268).

Physical Soil Properties - Changes in physical soil properties occur when ground based equipment makes repeated passes over the soil (Lull 1959). These activities compact and rut soils, reducing the amount of pore spaces in the soil. This in turn reduces the movement of water into and through the soil and also impedes root movement through soils, reducing a plant's ability to take up water and nutrients. Compaction and other physical soil disturbances such as displacement of the organic enriched top soil also affect soil microorganisms by altering the amount of carbon dioxide and oxygen in the soil. Changes in microorganism populations can affect soil productivity. All of these physical changes are concentrated on skid trails.

Soil Erosion

Erosion is infrequent on undisturbed forest soils for two reasons. First, organic matter provides a protective blanket on the soil surface that reduces the impacts of raindrops and allows water to move into the soil. Second, the surface soil below the organic layer is porous and allows water to move rapidly into and through the soil profile (Goldman et al. 1986 page 1.7).

Soil erosion can occur when the surface soil is compacted or when the loose surface soil and its protective layer of organic material are changed by management activities. Compaction, rutting and puddling reduce the movement of water into the soil and tend to channel water. As a result, water runs off (overland flow) and carries soil particles with it. Natural occurrences such as fire remove the organic matter from the soil surface. When organic matter is removed, soil pores can be plugged by fine soils moved by rainfall, resulting in overland flow and soil erosion.

Soil erosion is minimized by reducing the area where equipment operates by locating landings and skid trails on flat ground with a low or moderate erosion hazard and by using erosion control features such as water bars, vegetation, and slash placement. Management activities that leave organic matter on the soil surface also reduce soil erosion. By using these management tools in the proposed project soil erosion will be kept to a minimum.

Mass Failure

Mass failures are not major features or processes in either the Robert or Wedge Canyon Fire project area drainages. As mentioned above, there is a pre-fire slump that was caused by the placement of Forest Road 114 within the Trail Creek drainage within the Wedge Canyon Fire Area. There are also 2 slumps caused by the Robert Fire located in the Canyon Creek Inter-gorge just below the McGinnis Creek confluence and just south of FR# 803 approximately 0.4 to 0.5 miles west of the North Fork and FR# 803 confluence. Management activities are not proposed in proximity to these failures. BAER work will be completed this summer to stabilize the Trail Creek slump. Over time the Robert Fire slumps will stabilize as the vegetation within the Robert Fire Area reestablishes.

Restoration Activities Associated with Fire Suppression and Burned Area Emergency Response (BAER)

Fire suppression activities such as fire lines, safety zones and drop points have reduced soil productivity by soil compaction and soil displacement. They also have potential to increase soil erosion. However, all of the suppression activities were treated after the fire to reduce the effects on soils and other resources. These treatments included installing water bars, replacing topsoil both on hand and dozer fire lines and safety zones and seeding disturbed areas. These measures will be monitored the spring of 2004 to see if they are effectively controlling soil erosion. The reduction in soil productivity on sites affected by this disturbance will last for decades.

A BAER team consisting of resource specialists surveyed both the Robert and Wedge Canyon Fires and recommended emergency treatment to protect soils, water and wildlife. Some of these measures were installed last fall (detailed in Hydrology Section). Aerial seeding, culvert replacements, removals, and cleanings, armoring of drive through dips, and water barring are a few of the treatments that have been started last fall or are to be completed this summer/fall. Among the goals of these treatments is to protect the soil from erosion and where possible, to replace the productive surface soil that was removed during suppression activities. These practices have beneficial effects on soil quality, reducing soil erosion and encouraging vegetation growth.

3.6.3 Environmental Consequences

No significant issues related to soils were identified. The following Effects Indicators were used to focus the soils analysis and disclose relevant environmental effects: total acres and percent detrimental soil disturbance in the analysis area.

The analysis of effects for soils assumes that all of the practices outlined in Chapter 2, Design Criteria Common to the All Alternatives, would be implemented and would be effective. The analysis will show the expected amount of soil disturbance resulting from implementation of the no action and action alternatives, and will also describe the risk that the expected amount of disturbance would be exceeded.

Direct and Indirect Effects of the No Action Alternative

The No Action alternative provides a base line to evaluate the effects of the action alternative. The effects on soils are discussed as changes over time on soil productivity, soil erosion and mass failures.

Soil Productivity

The No Action alternative would not cause short-term effects on the soil resource over and above the existing condition. No additional road building, road decommissioning, or salvage harvest would disrupt the natural soil processes.

Organic Matter - The No Action Alternative would allow all standing dead trees to eventually fall over contributing large quantities of coarse woody debris. Needles and branches, especially in the areas with low fire severity would fall to the ground. Soil organisms would decompose the organic materials, adding humus to the soil. Nutrients associated with this material would slowly become available for plant growth. As the tree canopies close in and shade the soil surface, decomposition rates would slow allowing organic matter and nutrients to accumulate on the soil surface. This process would continue until another major disturbance such as fire or a windstorm opens the tree canopy and speeds up the recycling process again.

Vegetation would return to the site. It would reduce soil erosion rates and capture some of the nutrients released by the fire. This process would reduce the risk of nitrogen leaching into the water table. Vegetation is present and will reestablish quickly on the low burn severity soils. Moderate and high burn severity will re-vegetate more slowly, perhaps taking more than ten years. During recent field trips to the fire areas, vegetation was present along streams and within low or moderate burn severity areas.

Microorganisms - Microorganisms would return to the soil from adjacent or nearby unburned soils as conditions become favorable for them. Once they are back in the soil the nutrient cycling processes would begin again.

Physical Soil Disturbances - The No Action Alternative would cause no additional soil compaction, rutting, puddling, or soil displacement. Soil productivity in areas where past timber management compacted or rutted soils would slowly improve as plant roots, soil organisms, and freeze-thaw events loosen the soil. Most soil compaction would recover after 70 years without additional disturbance (Gonsior 1983 page 13-15).

Soil Erosion

The No Action Alternative would not negatively effect long-term soil erosion in the Robert and Wedge Canyon Fire areas. As vegetation returns the risk of soil erosion will decrease. Needles, twigs and large woody debris falling to the soil surface would further reduce the risk of soil erosion on low and moderate burn severity sites. In the short term, the No Action alternative would take longer than action alternatives to get fine and large woody debris on the ground where it would begin protecting the soil from erosion. This statement is based on the WEPP (water erosion prediction project) model runs made to determine the effects of harvest on soil erosion.

Mass Failures

The No Action alternative would not change the risk of mass failures.

Direct and Indirect Effects of the Action Alternative

Timber Management and Post-Salvage Fuels Treatment

Soil Productivity

The action alternative is designed to incorporate management practices that would reduce the effects from timber harvest on soil resources and insure that all activities occurring where previous management has not occurred meet the Regional Guidelines. These practices are described in Chapter 2 and the BMP Appendix C.

Organic Matter – Both the Robert and Wedge Canyon fires have greatly changed the amount of organic material on and in the soil. Forest management activities have the potential to further change the amount of organic matter on the ground, thus affecting soil productivity. However, the action alternative is designed to leave a variety of organic matter on the site, a practice that Harvey and others (1994, page12) found maintains productivity. The snag and coarse woody debris prescriptions are described in Chapter 2 under Project Design Features.

Both coarse woody debris (stems greater than 3 inches in diameter) and fine organic matter will be left on the harvested sites. The following is the list of materials or areas to be left for snags and coarse woody debris within the Robert and Wedge Canyon Project Areas based on the Deadwood Habitat Prescription Matrix (Appendix F) developed for the Project:

- All live trees.
- Green trees and snags that would have been retained but were felled due to hazards.
- Wildlife snags over 18” DBH with nest holes, broken top, conks, or pre-fire decay.
- Unmerchantable snags of all species and sizes.
- Coarse Woody Debris as described in the Flathead National Forest Land and Resource Management Plan.
- Black Cottonwood, aspen, paper birch, and ponderosa pine snags.
- Larch greater than 20 or 22 inches in diameter and greater than or equal to 10 feet in height or if the tree possesses a snag.
- Douglas-fir trees greater than 23 inches in diameter and greater than or equal to 10 feet in height or if the tree possesses a snag.
- Severely or moderately burned units smaller than or equal to 20 acres.
- Units larger than 20 acres that were: a) severely or moderately burned OR b) spruce dominated stands that burned at low intensity.

Slash treatment and fuels reduction work proposed for the project have the potential to remove the fine needles and branches that contain nutrients within a tree. Removing the fine organic matter component removes a portion of the nutrient supply for the soil and the vegetation. On sites where the fire severity was high, most of this fine material was consumed by the fire. However, sites with low or moderate fire severity have these materials. Where they exist they must be left on the site for at least one wet season. During that time the nutrients in the fine organic material will leach and be stored in the soil where they are available for plants to use (Harvey *et al.* 1999, p. 184, Garrison and Moore 1998, p. 48). In most units of low to moderate fire severity, where fine needles and branches remain on the trees, yarding of tops (i.e. whole tree yarding) would not occur. This fine organic material would be left in the units over at least one wet season to provide ground cover that reduces soil erosion rates and, if needles remain, provides nutrients. In some units, abundance of unmerchantable material may provide enough fine organic material to supply the needs for productivity. In addition, depending upon how long after the fire event the salvage harvest occurs, most if not all of the needles will have already fallen from the scorched trees, providing nutrients to the site.

After the leaching period, the sites would be evaluated by an interdisciplinary team to determine the need for treatment to reduce the amount of material on the ground. The need for treatment would be based on fire intensity that occurred on the site, soil conditions, slash size (large diameter material is less fire hazard than fine organic material) slash continuity, unit location in relation to surrounding fuel and forest conditions and existing or potential conifer regeneration. If fuel reduction is needed after the organic materials have been on the site for a wet season, the following design features would be used: where the use of ground based equipment is suitable, fuels reduction would be accomplished with excavators operating on existing skid trails. This method eliminates disturbance on additional areas and has minimal effect on soil physical characteristics (Land and Resource Management Plan Annual Monitoring Report, 1992 page 131-139). Where slopes are too steep for ground based equipment the reduction would be accomplished by hand piling concentrations and burning those piles or by jackpot burning concentrations of fuel. Burning would occur when soils are wet enough to reduce soil heating. It is not possible to predict what potential fuels treatments would occur on the sites, and post-salvage field reviews will provide the information needed for a final determination of slash treatment needs.

Based on these management practices for coarse woody debris, snags and fuels reduction, all units are expected to have adequate quantities of fine and coarse organic materials to provide nutrients, habitat for soil microorganisms and substrate for nutrient cycling. These post-harvest conditions would maintain soil productivity. All post-salvage fuels treatment would be designed to minimize or eliminate additional soil detrimental effects and would leave fine organic materials on the site for at least one wet season so nutrients would leach from the material before it is removed. In most cases the fine material would be left on site.

Microorganisms - The Robert and Wedge Canyon Fires have greatly changed the microorganism populations. Jurgenson and others (1977, page 248) note that after a fire, soil micro-flora recovers quite rapidly, frequently to levels greater than the original. Borchers and Perry (1990, pages 149 and 151) discussed the important role that less disturbed areas of soil play in inoculating soil that lacks or has reduced numbers of soil microorganisms. They state that unburned areas within burns, adjacent unburned areas, unburned large woody debris, and soils that have only minor amounts of disturbance contain propagules for fungi, bacteria and other soil organisms. The propagules are dispersed by wind, animals and other agents. The organic matter left on the harvest areas would benefit soil organisms by providing substrate for them to decompose, and habitat for them to survive in. The action alternative would leave both dead and live trees. This practice would leave a source of propagules for the burned sites in both Fires. The amounts of live and dead trees and their arrangement in the proposed harvest areas are described in Chapter 2 in the description of alternatives and under Snags and Downed Wood within Chapter 3.

Vegetation that returns to the harvested sites and the living vegetation that remains on the sites would utilize and store the nutrients released from organic matter. In addition the soil microorganisms also use and store nutrients. These factors reduce the amount of nutrients that would be leached from the site. The amount leached would be similar to the effects of historic wildfires.

Soil compaction, puddling, rutting and displacement change a soils ability to exchange oxygen and carbon dioxide, which affects the ability of soil organisms to survive. However, because all proposed harvest areas would be designed to reduce soil disturbance and meet the Regional soil guidelines favorable habitat for soil organisms would be maintained.

Timber harvest exposes soils to more sunlight and more moisture. Warm, moist conditions increase microbial activity and the amount of decomposition of organic matter that occurs on a site. In turn, nutrients would be available for plants (Harvey et al. 1994, page11).

Management practices discussed above that leave a variety of organic matter on the site and that minimize soil compaction would leave a favorable environment for the survival of soil organisms in the areas planned for salvage. No long lasting changes in long term soil productivity would occur as a result of the proposed activities.

Physical Soil Properties - The proposed cutting units where more than 15 percent detrimental soil conditions exist from previous management activities would be further monitored after implementation of the Robert-Wedge post-fire salvage logging project. This will be done to measure any additional increase in detrimental soil conditions caused by the salvage activities. At that time, mitigation measures would be implemented to reduce the detrimental soil condition to less than the amount that existed prior to implementing the project. For example, if a unit has 18 percent detrimental impacts before the salvage begins, and 25 percent after the salvage is completed, there must be 17 percent or less detrimental impacts after implementation of the project and restoration. Restoration would include rehabilitating landings and heavily used skid trails by either ripping, or shrub planting as appropriate for the site.

Harvesting of all other proposed cutting units is designed to insure detrimental soil effects are below 15 percent of the activity area. This would be achieved by implementing the management practices and logging method limitations described in Chapter 2 under Design Criteria and the description of alternatives, and in the BMP Appendix D.

McIver and Starr (2000, p. 14-16 and p. 45-46) discuss the amount of soil disturbance from various yarding systems. Helicopter yarding avoids all impacts from ground-based equipment within a cutting unit. Less than 1 percent of an activity area is disturbed and that is unlikely to be detrimental disturbance. Approximately 10 acres of soil would be disturbed for use as individual helicopter log landings and service areas. Landings would be located on flat areas away from streams and outside of the cutting units. Helicopter landings would be ripped to lessen compaction and increase movement of water into the soil when they are no longer needed. In some cases, roads would be used for helicopter landings, which would have no effect on soil productivity.

Skyline yarding with either the entire log suspended or with one end of the log suspended disturbs only the skyline corridor where the logs are pulled up hill to a road.

The corridors are narrower than skid trials used for ground-based equipment. They are compacted or displaced, but they occupy about 5 percent of the cutting area. All skyline corridors would have waterbars installed and slash placed on bare soil after salvage completion.

Ground based equipment compacts and/or displaces the soil where it operates. The soils that have high or moderate burn severity within the fire areas are more susceptible to the effects of ground-based equipment than the soils with low burn severity. Ground based equipment would not operate on soils mapped as moderate or high burn severity unless slopes, project design features and mitigation measures will ensure protection of the soil resource. These project design measures and BMPs are found in Chapter 2 and/or Appendix C. The management practices are designed based on burn severity and slope. Table 133 and Table 134 show acres of proposed harvest method for the Robert and Wedge Canyon Fires.

Table 133. Acres of Proposed Harvest Method by Alternative for the Robert Fire

Alternative	Acres of Helicopter Yarding	Acres of Skyline Yarding (summer/winter)	Acres of summer Ground Based Yarding on low burn/ Moderate burn/high burn severity	Acres of winter Ground Based Yarding on low burn/ Moderate burn/high burn severity	Acres of Non Harvested Ground within the Fire Boundary (Project Area)
No Action	0	0/0	0/0/0	0/0/0	12,852
Action	1,576	720/0	42/175/577	0/0/0	9,762

Table 134. Acres of Proposed Harvest Method by Alternative for the Wedge Canyon Fire

Alternative	Acres of Helicopter Yarding	Acres of Skyline Yarding (summer/winter)	Acres of summer Ground Based Yarding on low burn/ Moderate burn/high burn severity	Acres of winter Ground Based Yarding on low burn/ Moderate burn/high burn severity	Acres of Non Harvested Ground within the Fire Boundary (Project Area)
No Action	0	0/0	0/0/0	0/0/0	20,628
Action	1,108	193/28	0/109/512	0/418/364	17,896

Changes in soil productivity brought about by the implementation of an action alternative would be temporary. Natural processes such as freeze-thaw and root growth eventually loosen compacted soils. A literature review and assessment by Gonsior (1983, pages 13-15) mentions a maximum time for recovery of 70 years. Rutting and puddling are soil disturbances that are similar to compaction and would be expected to last a similar time. Displacement, the loss of topsoil, is a long term, and perhaps permanent loss of soil productivity. However, the management practices outlined in chapter 2 and Appendix C would reduce the amount of displacement, compaction and puddling to amounts that are within the Region 1 guidelines.

Soil disturbance from felling trees would be negligible and would be less than the natural amount of soil disturbance caused when trees are uprooted by wind. All trees would either be hand felled towards the skid trails or would be mechanically felled from the skid trails. Fuels reduction or site preparation work would be accomplished with excavators that operate on skid trails and do not cause additional soil disturbance. The harvest activities are designed to minimize the amount of soil disturbance off skid trails. Where skid trails already exist from previous activities, they would be reused, reducing the amount of additional detrimental soil disturbance.

These practices would maintain soil productivity at levels that would meet the Regional soil quality standards.

Soil Erosion

Forests generally have very low erosion rates unless they are disturbed. Common disturbances include wildland fire, and harvesting operations. The impact of these operations, however, lasts only for a short time, perhaps one or two years. After that, the re-growth of vegetation covers the surface with plant litter, and potential erosion is reduced.

Reducing the amount of bare, disturbed soils in harvested areas minimizes soil erosion. The practices that maintain soil productivity, such as leaving organic material on the soil surface and reducing the area impacted by skid trails also reduce the risk of soil erosion. In addition, implementing specific erosion control measures such as waterbars, placing slash on disturbed soils, and vegetating disturbed soils would also reduce erosion.

With the implementation of the management practices described in Chapter 2, the total amount of soil erosion caused by the proposed activities would be small and would decrease with time as vegetation returns to the soils. The WEPP (water erosion prediction project) model was used to estimate soil erosion from post harvest conditions.

Results from the WEPP Model indicate that erosion caused by the Robert-Wedge Salvage Sale will increase by 3,769 acres in the Robert and 284 acres in the Wedge Canyon Project Areas over natural conditions. This is a small amount considering the conditions caused by the fire will initially (1st year) produce 79,210 and 46,332 tons of erosion in the Robert and Wedge Canyon Project Areas respectively. Treatment implementation will also produce approximately 159 (Robert) and 373 tons (Wedge Canyon) of sediment to streams above natural conditions. This sediment is approximately 1% of the sediment that will be produced to streams naturally by the fires.

Mass Failure

The shear strength of roots provides important structural reinforcement and buttressing on slopes. Live roots increase the stability of soils on steep slopes by binding the soil to the underlying fractured bedrock. When live trees are harvested these attributes change and the risk of mass failure increases. However, the dead roots remaining after the fire-killed trees are harvested will bind the soils to the underlying bedrock the same as if the trees had not been salvaged. Planting trees and shrubs, as would happen as part of the post fire restoration, will gradually stabilize soils. The action alternative includes reforestation, which would further stabilize soils. Critical mass failure prone areas are not in this proposal. Skid trails will be built to avoid steep slopes and soils with the potential to produce severe erosion.

Road Management

Soil Productivity

Roads change soil physical properties. The proposed road management would have a long-term benefit to soil productivity. No new permanent or temporary roads will be constructed with this project. The project will close and decommission roads. Approximately five miles of open yearlong/seasonally open road would be closed yearlong to wheeled motorized vehicles. In addition to changes to open roads, approximately 16 miles of road would be decommissioned in both the Lower Whale and Canyon McGinnis grizzly bear subunits. Road decommissioning would include actions to minimize the potential for future sedimentation of streams. These actions would include placement of numerous waterbars, culvert removals, grass seeding, slash or debris placement on roads, and the planting of shrubs.

This activity would slowly increase soil productivity on the decommissioned roads. The lack of traffic would favor increased growth of vegetation, which would in turn increase the amount of organic matter in the soil and gradually loosen compacted soils. This process could take decades to bring productivity levels to what they were previous to road construction. Roads that remain on the forest road system but are closed to use would also see slowly improving soil productivity, but occasional traffic would limit its recovery.

Soil Erosion

Road decommissioning would cause a short-term increase in soil erosion. Disturbed soils adjacent to streams would be at risk of producing sediment. However, decommissioning would be designed to minimize the exposure of bare soils and thus would minimize the amount of soil erosion and sediment. In the long term there would be a net decrease in soil erosion. Sediment production is discussed in detail in the hydrology analysis. Roads that remain on the forest road system but are closed to use would also have less soil erosion in the future as vegetation returns to the site.

Mass Failure

New permanent roads would not be built with the action alternative, thus the risk of a new road causing a mass failure is eliminated. Roads that are decommissioned will have a reduced long-term risk of road-associated mass failures.

Cumulative Effects

Past Actions

Past activities, which affect soils, include timber harvest and associated activities such as site preparation, reduction of fuels, and skid and landing construction. In addition, road and trail construction have also occurred. These are the main activities that disturb soils in the project area. Approximately 3,752 acres of soil are disturbed by past harvest activities and road construction within the Robert Fire Cumulative Effects Area. This represents about 13 percent of the 29,346 acre soil analysis area. Approximately 6,164 acres of soil are disturbed by past harvest activities and road construction within the Wedge Canyon Fire Cumulative Effects Area. This represents about 7 percent of the 94,389acre soil analysis area.

Current and Reasonably Foreseeable Actions

Trees will be planted in burned-over plantations over the next few years. Re-vegetation and reforestation of sites throughout the Wedge Canyon Fire area would improve soil conditions by adding organic matter to the soil and by loosening compacted soils **(ROBERT AND WEDGE CANYON FIRES)**.

Trail Creek Road Slump repair to be completed in the summer/fall of 2004 with BAER funds. Stabilization of this slump will reduce sediment entering Trail Creek, improving the water quality and aquatic habitat of the system **(WEDGE CANYON FIRE).**

BMP Project - Roads and culverts throughout the fire area require improvements to meet best management practices (BMPs) and accommodate elevated levels of run-off anticipated from the fire. Activities will begin in the summer of 2004 and will likely continue for 2 years. This road maintenance work, which includes roads planned for timber hauling associated with the proposed harvest activities, is addressed in the Burned Areas Road Maintenance Project. This project refers to a program of road maintenance activity to apply Best Management Practices on up to 328 miles of forest road in or near areas that were burned by wildfire on the Flathead National Forest during 2003. Approximately 84 miles of road in the Robert Fire and 54 miles of road in the Wedge Canyon Fire will be maintained. Types of road maintenance work will include:

- Maintenance of road drainage structures including cross drains
- Brushing
- Maintenance of fill slopes, cut slopes, and ditches
- Maintenance of roadway surfaces
- Maintenance of bridges and culverts
- Removal of culverts
- Replacement of undersized culverts
- Upgrading or removing structures to provide for fish passage
- Installation of additional road drainage features including rolling dips

Installing BMPs to several miles of roads in the Robert and Wedge Canyon Fire areas will reduce the amount of erosion from the roads. This effects water quality and the drivability of the roads, but has little or no effect on soil productivity. The installation of larger culverts on roads open year-long or seasonally would reduce the potential for road associated erosion due to culvert failures. This action would also reduce the risk of mass failures in stream channels below culvert failure sites. This activity would have no effect on soil productivity **(ROBERT AND WEDGE CANYON FIRES)**.

Commercial Mushroom Harvest – A signed decision authorized commercial and personal mushroom harvesting within the Robert and Wedge Canyon Fire areas. Mushroom harvest began in May 2004 and is expected to be completed in August 2004. Commercial mushroom pickers would be dispersed over a wide area. The detrimental effects on soils would be difficult to measure and it would be equally difficult to estimate their effect on soil productivity or erosion. Measuring the effect would be like measuring the effect of wildlife moving through a forest. Picking mushrooms would not affect mass failure potential **(ROBERT AND WEDGE CANYON FIRES)**.

Forest Roads 1672 and 5234 will be decommissioned in the summer of 2004 as per the Hornet Wedge Decision Notice. These activities have favorable effects on soils, allowing productivity to slowly increase as vegetation grows, loosening compacted soils and adding organic matter to the soil **(WEDGE CANYON FIRE)**.

Forest Road 1671 will be bermed this summer as per the Hornet Wedge Decision Notice. This will allow vegetation to grow on the road, ultimately breaking up soil compaction-improving soil productivity **(WEDGE CANYON FIRE)**.

Special forest product gathering for personal use is likely to occur, such as berry picking, firewood and Christmas tree cutting, evergreen bough and cone collection, particularly in those areas unaffected by the fire. Like mushroom collecting, measuring the effects from this activity on soil productivity and erosion would be difficult **(ROBERT AND WEDGE CANYON FIRES)**.

The closure order for firewood cutting in the fire area currently in effect will be rescinded after harvest activities. Additional signs will be placed in riparian areas prohibiting firewood cutting in these areas (which are also specified in all firewood cutting permits) once the closure order is lifted **(ROBERT AND WEDGE CANYON FIRES)**.

Recreational public uses such as sightseeing, hiking, camping, firewood collecting, fishing, hunting and snowmobiling are expected to continue and increase over the next 10 years. The most likely activity to effect soils would be firewood harvest (after the closure order is lifted). This activity could reduce the amount of large woody debris along open roads. Dispersed recreation has potential to cause soil compaction in areas where use is concentrated such as campsites. This amount of effect on the soils would be difficult to measure **(ROBERT AND WEDGE CANYON FIRES)**.

BAER monitoring in the fire affected area; bull trout habitat, seeding/revegetation, whitebark pine, weeds, and heritage site. No impacts will occur to soil productivity or soil erosion from this activity **(ROBERT AND WEDGE CANYON FIRES)**.

Further private land development will permanently commit soil resources producing minimal localized impacts to soil productivity. Impacts will be low from a watershed scale perspective **(ROBERT AND WEDGE CANYON FIRES)**.

Weed monitoring and possible treatment would help protect the integrity of native plant communities in the Robert and Wedge Canyon Fire areas. This would protect soil quality on these sites by maintaining plant cover that supplies soil organic matter and cover to protect the soil from erosion. The decision tree in the Weed EA would be followed, which was designed in part on soil characteristics and how the soils are affected by pesticides **(ROBERT AND WEDGE CANYON FIRES)**.

The Montana Department of Natural Resources and Conservation (DNRC) is currently logging Section 16 (approximately 640 acres). Logging was initiated in the Fall of 2003 and will be completed by the fall of 2003. Providing current project design measures and BMPs are implemented **(WEDGE CANYON FIRE)**.

Cumulative Effects Within the Soil Analysis Areas

The cumulative effects analysis for the Robert and Wedge Canyon analysis areas includes both existing soil disturbances from past activities and the expected disturbances from the proposed activities. This analysis is a modeling exercise that makes use of data from the timber stand database, road location GIS data, and the results of past monitoring, literature searches, and discussions with other soils personnel in the Forest Service. Table 135 displays the estimated total acres of detrimental soil disturbances. There are no Regional or Forest standards/guidelines for the amount of area impacted within an analysis area. This information is provided to indicate the overall watershed condition and to provide a comparison of the effects by alternative.

Table 135. Effects of Past, Present and Proposed Treatments on both the Robert and Wedge Canyon Soil Analysis Areas

Alternative	Existing disturbance (roads, trails and timber harvest, including hazard tree removal) in acres	Proposed Disturbance from Forest Management Including Skid trails and Landings and Fuels Reduction Treatments	Changes from Road Decommissioning in Acres. (These acres will result in improved soil productivity and reduced erosion over time)	Total acres Disturbance / % of Analysis Area (52,524 acres in soil analysis area)
Action Alternative for Robert Soil Analysis Area (29,346 acres)	3,750	415	-44	4,108/14%
Action Alternative for Wedge Canyon Soil Analysis Area (94,389 acres)	6,148	411	-4	6,555/8.0%

[1]The column 'Changes from Road Decommissioning' includes decommissioning occurring from previous decisions that would still occur under the no action alternative.

[2]All alternatives are designed to meet the Region 1 Soil Quality Standards.

Cumulative Effects in Activity Areas (cutting units)

Cumulative effects will be assessed within each activity area. These effects will consist of all past, present, and proposed impacts to soil productivity. All units with previous management activity will be reviewed on the ground during the spring and summer of 2004 to quantify the effects from past timber harvest and determine if existing levels of detrimental soil disturbance exceed the Regional soil quality guides. These results will be displayed in the final Robert- Wedge Post Fire Salvage EIS.

Monitoring will occur again following project implementation. The guidance in Forest Service Manual Supplement No. 2500-99-1 would be followed. It states that where an activity area such as a cutting unit has had previous management that caused less than 15 percent detrimental soils conditions, the cumulative detrimental effect of the proposed activity following project implementation and restoration must not exceed 15 percent detrimental soil conditions. It further states that where more than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects from project implementation and restoration should not exceed the conditions prior to the proposed project and should move towards a net improvement in soil quality. This direction would be followed for the proposed second entries within the Robert and Wedge Project Areas. Restoration activities such as reclaiming landings and skid trails would be the primary means to restore soil quality.

The Risk of Exceeding Soil Quality Guidelines

Detrimental soil conditions would not be significantly increased on the units yarded with helicopter or with skyline systems. Helicopter yarding would disturb one percent or less of the soil surface (McIver and Starr 2000, pages 14-16 and pages 45-46). During monitoring of helicopter logging on the Flathead National Forest it is difficult to see or measure soil disturbance (Basko, 2003 personal communication). Monitoring of the Happy Trails timber sale showed no measurable or observable soil disturbance caused by helicopter logging. The monitoring sheets for Happy Trails are in the project files. Skyline yarding is proposed only for units that were previously skyline yarded. Purser and Cundy (1992), found skyline yarding disturbed about 5 percent of a cutting unit. Most skyline corridors would be reused. If all new corridors were established the total disturbance would be about 10 percent. Skyline units will meet the Regional guidelines.

Ground based yarding of units that were not previously managed is expected to meet the Regional Guidelines if it is done according to the management practices listed in Chapter 2. The skid trails and landings would be designed to occupy less than 15 percent of the area. If they need to be closer together, they would then be protected by a slash mat, which monitoring has shown to be effective at protecting soil from compaction, rutting, puddling and displacement (Soil Monitoring Report, Help Creek Timber Sale, 1999). The requirements for a slash mat are described in Chapter 2. Winter logging over snow or frozen ground is another option available to protect soils during ground based yarding of trees. Several monitoring reports show winter operations greatly reduce the effect on soils (Sula State Forest Fire Salvage Monitoring Report, 2002 pages 12-15 and Land and Resource Management Plan Annual Monitoring Report, 1992 pages 131-139).

Ground based yarding of units that were previously managed have a higher risk of exceeding Regional guidelines than do helicopter, skyline yarding or ground based yarding on units that were not previously managed. Units with proposed ground based yarding and previous management will be monitored after salvage harvest. If detrimental soil disturbance exceeds 15 percent, we will implement restoration measures. However, all management practices are designed to meet the Region 1 Soil Quality Standards either by affecting less than 15 percent of an activity area with detrimental soil disturbance or not exceeding conditions that existed prior to project implementation and moving toward improvement in soil conditions. Restoration of soils is not part of alternative design and would be used only if monitoring after project implementation shows that the soil quality standards were exceeded.

Restoration Effectiveness

If needed, restoration activities to improve soil conditions would include ripping heavily used skid trails and landings that are compacted. The goal would be to reduce soil compaction and meet the direction provided in Region 1 Supplement 2500-99-1 (See Regulatory Framework at end of this section). Several studies discuss the effectiveness of ripping as a soil restoration activity. Studies cited by Froehlich and McNabb (1983 p. 22-23) showed up to 39 percent improved seedling survival and growth after tilling compacted soils. The same study showed height growth gains of 8 to 73 percent.

A publication by the British Columbia Ministry of Forests (Bulmer, 1998 p. 10) cites a study by Dick, et. al. (1988) that found rehabilitation treatments of subsoiling (tilling) restored biological processes that were reduced by soil compaction. In general, tilling or subsoiling a compacted soil improves productivity by reducing the resistance of soil to root penetration, and providing improved soil drainage and aeration to enhance seedling establishment and tree growth (British Columbia Ministry of Forests (1998 p. 13) and improve the environment for soil organisms.

The Risk of Exceeding Soil Quality Guidelines with a Second Entry

Skyline yarding has a low risk of causing cumulative soil effects that exceed the soil quality guidelines because all units proposed for skyline logging were skyline yarded in their previous management activities. It is likely that many existing skyline corridors would be reused. However, even if all new corridors were used, the total detrimental soil disturbance would be about 10 percent, which is within the Regional Guidelines.

Units that are proposed for helicopter yarding have a low risk of causing cumulative soil effects that exceed the soil quality guidelines, because helicopter yarding disturbs one percent or less of the activity area and often causes no detrimental soil effects.

Yarding with ground-based equipment has the highest risk of causing cumulative effects that exceed the soil quality guidelines. The effective implementation of the mitigations and management practices built into the activities is crucial. These units would be monitored after project completion. If the guidelines are exceeded, heavily used landings and skid trails would be restored with the goal of either reducing impacts to less than 15 percent of the area or to less than existed before salvage harvest was implemented.

Regulatory Framework and Consistency

Region 1 Soil Quality Standards - All proposed activities are designed to meet the Region 1 Soil Quality Standards. These standards require that soil properties and site characteristics be managed in a manner consistent with the maintenance of long-term soil productivity, soil hydrologic function, and ecosystem health.

Region 1 Supplement 2500-99-1 defines an activity area as a land area affected by a management activity to which soil quality standards are applied. An example is a harvest unit within a timber sale. It also states that in areas where less than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects of the current activity following project implementation and any needed restoration activities must not exceed 15 percent. In areas where more than 15 percent detrimental soil conditions exist from prior activities, the cumulative detrimental effects from project implementation and needed restoration activities should not exceed the conditions prior to the planned activity and should move toward a net improvement in soils quality.

Forest Plan Management Direction - Forest wide standards for soil resources in the Forest Plan (USDA 2001, page II-46) are:

1) "Ensure that all resource management activities will maintain soil productivity and minimize erosion through implementation of Erosion Prevention Standards (Engineering Handbook Supplement).

2) "Design or modify all management practices as necessary to protect land productivity".

The soil analysis indicates that all alternatives and all activities proposed by the alternatives would meet the Region 1 Soil Quality Standards through the implementation of management practices outlined in Chapter 2 and restoration of landings and heavily used skid trails, if needed, to reduce the total amount of detrimental soil impacts. All Forest Plan management direction would be met by the proposed alternatives.

3.7 FISHERIES

3.7.1 INTRODUCTION

ANALYSIS AREA AND INFORMATION SOURCES

Information for this analysis has been gathered from a variety of sources. The Flathead National Forest (NF) and Montana Department of Fish, Wildlife, and Parks (MDFWP) have conducted site-specific fish habitat condition and population status inventories within the watershed for more than twenty years. Forest Service biologists prepared a baseline Biological Assessment (BA) of the status of bull trout in 1998 and updated it for the North and Middle Forks of the Flathead River in 2000 (USDA Forest Service 2000).

Quantitative habitat and biological data for this report was gathered from reports for Canyon Creek in the Robert Fire area, and Teepee, Whale, Shorty, and Trail Creeks in the Wedge Canyon Fire. In addition, Forest Service biologists prepared a Burned Area Emergency Stabilization and Rehabilitation (BAER) Plan for the Robert and Wedge Canyon Fires in the fall of 2003. Most of the stream condition information is from this report and the BA prepared for the Burned Areas Road Maintenance Project on the Flathead National Forest (USDA Forest Service 2004). Electrofishing surveys conducted by the MDFWP provide the basis for the westslope cutthroat trout information. Flathead NF R1/R4 survey data from 1995 for Shorty Creek, and 1996 from South Shorty Creek, were also used. Temperature data from a variety of sources and some sediment monitoring data are included as well.

The fisheries analysis area for this project encompasses a range of spatial scales which to large degree reflect the current status of bull trout (*Salvelinus confluentus*). This analysis area includes the North Fork Flathead River (952 square miles; 609,280 acres) and Flathead Lake (1,144 square miles; 732,680 acres). The Flathead River below the dam is not part of this analysis. The construction of Kerr Dam in 1938 isolated fish populations above the dam from populations in the lower river. Similarly, dams in both the South Fork Flathead River and the Swan River have isolated fish populations. Access to these river systems is no longer available to fish residing in and above Flathead Lake (Weaver and Fraley 1991). The broad-scale analysis area for this project, therefore, includes the upper Flathead basin, which encompasses Flathead Lake, the North and Middle Forks of the Flathead River, and the intervening river channel that connects them.

At a finer resolution, this analysis focuses primarily upon the Canyon Creek drainage (including Kimmerly, Depuy and McGinnis creeks) and the Deep Creek drainages for the Robert Fire area, and the Whale Creek (including Shorty Creek), Teepee, and Trail Creek drainages for the Wedge Canyon Fire. All of these creeks flow west to east and join the North Fork above the confluence with the Middle Fork.